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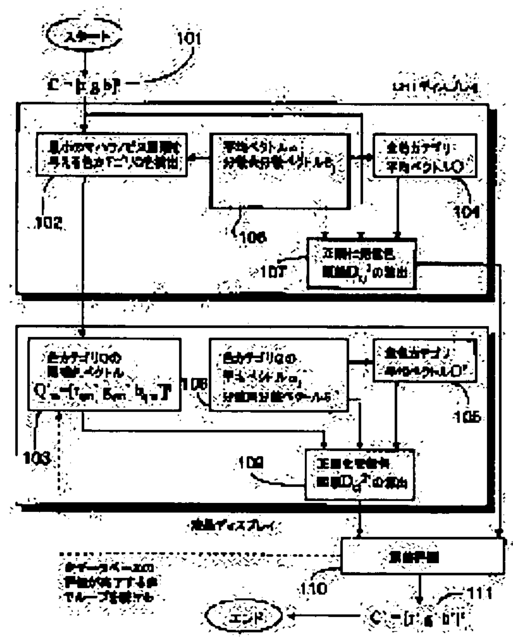
(54) COLOR INFORMATION EXCHANGING METHOD AND DEVICE CHARACTERISTIC ADJUSTING METHOD

(57)Abstract:



PROBLEM TO BE SOLVED: To improve the color reproducibility of image by exchanging color information so as not to make the impression of entire image by different by dividing a color space, which is formed by chrominance signal data for each transmission device and each reception device, into plural color categories while collecting colors sensed by an observer, and exchanging the color information between the same categories.

SOLUTION: A transmission color vector C on a CRT display is expressed by C=[γgb]t (101) and concerning the color category to which that vector belongs, a color category Q applying a minimum value among 11 pieces of maha;lnobis' distances D2 is detected (102). Since this color category Q becomes the color category to which the transmission color vector belongs, a color data group Qm' (103) classified into the color category on the liquid crystal display becomes a mapping point candidate. Then, these color candidate color vectors Q' (105) form a color data group, in which the mahalaobis distance of color category is made minimum among all the light-emitting colors on the liquid crystal display.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention is a technique about the color reproduction and color adjustment which can be used for all input image devices, such as a camera, a scanner, a monitor, and a printer, or an output image device.
[0002]
[Description of the Prior Art] Colorization of all image devices progresses in recent years, and the opportunity for office use or a home youth to also use a color image and a color document has increased. In connection with this, the color reproduction technique of each device simple substance also shows development, and high-performance-izing is remarkable.
[0003] however, fusion of the color reproduction which the open system appeared and has grown with the device of former each from the advance of a network technique and the increment in social use, and a color tone ready technique -- a degree -- it has risen to surface as a technical problem. For example, the NTSC signal has so far been used only for the color signal transduction of a broadcasting mold. In this case, management of a color is enough made by specification by the side which receives color information, and only the broadcasting station of an origination side should carry out a color management. However, the color signal transduction of a bidirectional mold must be used according to construction of the network infrastructure of a high bandwidth mold, each home and each office must become information dispatch origin, and the color management which the broadcasting station which has a know how has so far performed must be realized to some extent also in each home and each office. Information, for example, a photograph etc., to specifically send must be changed into the NTSC signal, without the addresser itself degrading color reproduction nature. Furthermore, not only the conversion to an NTSC signal but color information interchange with an open system needs interconnect of all chrominance signals.
[0004] "A difference in the color reproduction range between each device" and "a difference in an observation environment" are raised as a big technical problem among the problems of the color reproduction resulting from opening-ization of such color communication, and color adjustment.
[0005] "A difference in the color reproduction range between each device" is explained first. Generally, compared with printed matter, the color reproduction range of a CRT display is wide, and it can display a vivid color. Then, the problem that the color which the designer meant cannot express by the printing lifter occurs to print CG (Computer Graphic) image by the printer. On the other hand, when it excels in an umbra, i.e., a part with low brightness, at gradation nature compared with CRT and the picture of printed matter is displayed on CRT, a problem generates printed matter to the expression nature of the detail of the shadow section. The problem of the difference in the color reproduction range between such each device is fundamentally unsolvable from the limitation that a certain device cannot present a color physically. However, in the open system mentioned above, any constraint cannot be found and the exchange of color information is performed between each device. Therefore, a certain measures must be taken in the form where degradation of color reproduction nature is suppressed to the minimum. For this

reason, as for "color-gamut mapping" which maps the color exceeding the color reproduction range of the device of a receiving side in color reproduction within the limits, ED is furthered briskly in recent years.
[0006] There is an approach indicated by one of them at "color-gamut compression (II) in CG image" (color forum JAPAN' collection [of 96 summaries] P21- P24). This is [Equation 1].

$$\Delta E = \sqrt{\left(\frac{L^*_1 - L^*_2}{K_l}\right)^2 + \left(\frac{C^*_1 - C^*_2}{K_c}\right)^2 + \left(\frac{H^*_1 - H^*_2}{K_h}\right)^2} \qquad (1)$$

It is the approach of performing color-gamut mapping by chrominance-signal pair from which the becoming color difference type is defined and this color difference becomes the minimum. (several 1) -- setting (L*1, H*1, C*1) -- it is the colorimetry value of the color which CG image on a monitor has, and color difference **E becomes min for color-gamut mapping -- as (L*2, H*2, C*2) -- it is determining within the color reproduction of a printer. It is Kc, when several sets of (kl, Kh(s), Kc(s)) were set up, the conditions of mapping were changed and the comparison of a subject-copy image and a reappearance image was performed. >= Kh >= When it sets up with Kl, it is reported that desirable color-gamut mapping was subjectively realizable. Kc >= Kh >= The mapping approach which becomes Kl will become the expression of "compressing in the saturation direction while fixing lightness if possible and also changing a hue to some extent", if the text of bibliography is quoted as it is.
[0007] Moreover, "Nikkei electronics As shown in drawing 12 , lightness and a hue are kept constant at no.570 and P101 of 1992.12.21", only saturation is adjusted, and the approach of mapping in the rim of the color reproduction range, the method of compressing all points smoothly aiming at the center-of-gravity section of a color space, avoiding a saturation fall, and determining a mapping point, as shown in drawing 13 , etc. are shown.
[0008] As mentioned above, in case all the introduced conventional approaches determine the mapping direction, they are observing the degree of preservation of the three attributes of color of the color of lightness, a hue, and saturation. Since the image which has the color completely same between each device fundamentally is unreproducible, if priority is given to preservation of which attribute, or if priority is given to degradation of which attribute, the approach of mapping will be determined from the decision criterion whether the impression of the appearance of a reappearance image becomes better. In the case of drawing 12 , weight is set to preservation of lightness and a hue, and it sacrifices the fall of saturation for it. Therefore, in the above and the conventional example, the multi-statement of the amount of adjustments of the attribute of three colors is carried out altogether, a reappearance image is created in the total combination, and the procedure of adopting the amount of adjustments of the three attributes of color most used for the high reappearance image of subjectivity evaluation as the mapping approach is taken.
[0009] Next, "a difference in an observation environment" is explained. The colorimetry system which Commission Internationale de I'Eclariage CIE defines is effectively utilized in the design of a color reproduction system. If the colorimetry value of two colors is in agreement, it can be judged that the two colors are the same. However, two colorimetry values which all the colorimetry systems that CIE advised fixed lighting conditions, and the bottom of different lighting was shown are incomparable the place by the present. For example, a colorimetry value cannot estimate the comparison of the color of the reappearance image compared with the subject-copy image compared with the fluorescent lamp, and the incandescent lamp.
[0010] However, it is very difficult for the completely same lighting condition and the "observation environment" which consists of a condition, observation distance, etc. of a background of an observation image further to find out the completely same scene in everyday life. Since the amounts of light reflected on the surface of a display differ in them when the same CG image is observed to daytime and late at night on the same display, even if the fluorescent substance independent luminescence property of a display is fixed, contrast completely differs from a tint etc. and it is visible to them. The input-output behavioral characteristics of a monitor also including the effect of outdoor daylight changed. Moreover,

the color information interchange between the remote places through a network is a case which the need of controlling a color between observation environments which divide and are different produces. When the sources of the illumination light differ by the addresser and addressee side, generally the pair of the color perceived by the same color among both is called a "correspondence color." And when the color by the side of an addresser is illuminated in the source of the illumination light by the side of an addressee, it calls it "correspondence color prediction" to predict whether it is visible to what kind of color. Change of the input-output behavioral characteristics of the single device by change of an observation environment is also one gestalt of correspondence color prediction.

[0011] This correspondence color prediction is described by change of the adaptation condition of a visual system over lighting ("color dynamics" (Ota ** work) Tokyo Denki University Press (1993) P184 - P191). von Kries proposed the "adaptation equation" noting that the tristimulus values of a perceived color changed to the ratio of the tristimulus values which the source of the illumination light has at linearity. Moreover, Naya applies illuminance level and the reflection factor of a background to the parameter of an adaptation equation, and is the Kherson Judd effectiveness (if a gray scale is illuminated with chromatic color light). bright gray -- the hue of the illumination light -- sensing -- dark gray -- the hue of the complementary color -- sensing -- the Sutee Bunce effectiveness (if an illuminance is changed and the group of an achromatic color is illuminated) And the gray more dark in white of bright gray is more visible to black in a high illuminance, it is the hunt effectiveness (if an illuminance is changed and a chromatic color is illuminated). With the adaptation equation of the nonlinear mold which can predict that it goes up and is visible according to an illuminance etc., the saturation (KARAFURUNESU) perceived is raising the precision of correspondence color prediction.

[0012]

[Problem(s) to be Solved by the Invention] However, it leaves some technical problems to the color-gamut mapping approach by the above-mentioned conventional approach, and correspondence color prediction.

[0013] First, since unique relation is not built between the amount of adjustments of a hue, saturation, and lightness, and color reproduction nature, if color-gamut mapping does not test all the amounts of adjustments that can be considered, the technical problem which cannot specify the best color reproduction image exists.

[0014] Moreover, correspondence color prediction is usable only under limited observation conditions, has a big gap to an actual use situation, and has the technical problem that practical level is not reached.

[0015] It aims at offering the color information-interchange approach and the device property adjustment approach of enabling practical correspondence color prediction which this invention solves the technical problem of the above-mentioned conventional technique, and can determine the approach of color-gamut mapping uniquely, and absorbs the difference among observation conditions.

[0016]

[Means for Solving the Problem] In color-gamut mapping, since the same color cannot be fundamentally shown between each device, it becomes a target to exchange color information so that the overall impressions of the image in each device may not differ as much as possible. For example, if it expresses by the tint, as for "a red flower", a printing lifter should also be "a red flower" on CRT, and it is not desirable that the categories of the color which a flower has like "a yellow flower" and "an orange flower" differ. Furthermore, a way with the red of a flower "more powerful than the red of an apple" when it is "stronger [the red of a flower] than the red of an apple" on CRT is desirable, and it is not desirable when "the red of a flower is weaker than the red of an apple". [a printing lifter]

[0017] Thus, in order to make it the overall impressions of an image not differ as much as possible in color-gamut mapping, it is important that reversal of a tint and discontinuity do not occur between each device over the whole (b) image with the same color category of (a) same pixel.

[0018] So, in this invention, it divides into two or more color categories by settlement of the color which an observer perceives the color space which chrominance-signal data form for every dispatch device and receiving device, and color information is exchanged only between the same color categories.

[0019] That is, the drive signal in the receiving device of the pixel perceived "red" with the dispatch

device is selected from the chrominance-signal data constellations perceived "red" on a receiving device.

[0020] Moreover, in order to determine a receiving color vector from the inside of the same color category, a dispatch color vector determines this invention as the center-of-gravity point of all the color categories in a dispatch device color space according to the relative physical relationship which it has.
[0021] For example, when the center of gravity of near and the "green" color category which is the "red" complementary color is further from the center of gravity of the color category of "Orange" where the location with the dispatch color vector perceived "red" resembled "red", the chrominance-signal data near "Orange" should be chosen as the receiving color vector from "it is green." And when the distance of a dispatch color vector and the center of gravity of "Orange" is 1/2 of the distance of a dispatch color vector and a "green" center of gravity in the color space of a dispatch device, the receiving color vector of the center of gravity of "Orange" and the distance which it has chosen in receiving device space should be 1/2 of distance with a "green" center of gravity.
[0022] Thus, reversal of a tint and color information interchange which discontinuity" does not generate are realizable over the whole "image by selecting the receiving color vector for every pixel so that the relative location of the distance which a dispatch color vector has with the center of gravity of each color category may be materialized also in the color space of a receiving device.
[0023] Moreover, in this invention, the modeling of the color category is carried out according to a standard normal distribution. An observer searches for the mean vector and a distributed covariance vector by two or more chrominance-signal data constellations classified into each color category in consciousness, defines a standard normal distribution for every category, and makes this the probability of occurrence of the color vector from each color category. And the color category of a certain pixel is taken as a color category with the highest probability among the probability of occurrence which each color category has.
[0024] Moreover, the distance in which a dispatch color vector has this invention with the center of gravity of each color category, and a receiving color vector use the center of gravity of each color category, and the Mahalanobis distance asked also for the distance which it has from a mean vector and a distributed covariance vector.
[0025] A dispatch chrominance signal searches for all the color category center-of-gravity points given as an average of the center-of-gravity point of all color categories, and describes the center-of-gravity point of each color category, and the relative location which it has in the normalization dispatch color distance which broke the Mahalanobis distance from all color category center-of-gravity points to a dispatch color vector by the Mahalanobis distance from said all color category center-of-gravity points to each color category center-of-gravity point.
[0026] A receiving chrominance signal searches for all the color category center-of-gravity points given as an average of the center-of-gravity point of all color categories, and describes the center-of-gravity point of each color category, and the relative location which it has in the normalization receiving color distance which broke the Mahalanobis distance from all color category center-of-gravity points to a receiving color vector by the Mahalanobis distance from said all color category center-of-gravity points to each color category center-of-gravity point.
[0027] It is determined that the mapping point of a receiving color vector will become equal to normalization dispatch color distance [as opposed to all color categories in the size relation of the normalization receiving color distance over all color categories].
[0028] As mentioned above, by carrying out the modeling of the color category by the standard normal distribution from an observer's response, the color category of the pixel of arbitration could determine this invention in the dispatch device and the receiving device, and when a receiving device side also maintains the relative location which the center-of-gravity point of a dispatch color vector and each color category has further, it has secured unrealizable "uniqueness" by the conventional color-gamut mapping method.
[0029] In addition, the color information-interchange approach is applicable also to correspondence color prediction. Although the conventional correspondence color prediction can be performed only

under the conditions on which observation environments, such as lighting, were controlled completely, this invention can perform correspondence color prediction under the observation environment of arbitration by classifying the color category by the observer.
[0030] Moreover, if a dispatch device and a receiving device replace that it is the former condition and present condition voice of the single device from which input-output behavioral characteristics changed, respectively, the above color information-interchange approach is applicable also to the device property adjustment approach.
[0031] As mentioned above, according to this invention, the approach of color-gamut mapping can be determined uniquely. And property adjustment of the single device from which input-output behavioral characteristics changed by improvement in the color reproduction nature of the image between the devices with which observation conditions differ, physical fluctuation and physical degradation of a device, or change of observation conditions etc. is realizable.
[0032]
[Embodiment of the Invention] By dividing into two or more color categories by settlement of the color which an observer perceives the color space which chrominance-signal data form for every dispatch device and receiving device, and exchanging color information between the same color categories, invention of this invention according to claim 1 can exchange color information so that the overall impressions of an image may not differ, and it can improve the color reproduction nature of an image.
[0033] By selecting a receiving color vector out of the chrominance-signal data constellation of the receiving device classified into the same color category as the color category to which the dispatch color vector of the color information which a dispatch device disseminates belongs, invention of this invention according to claim 2 can exchange color information between the same color categories, and it can exchange color information so that the overall impressions of an image may not differ.
[0034] By selecting a receiving color vector so that the physical relationship of a dispatch color vector and the center-of-gravity point of each color category of a dispatch device may be saved also in the physical relationship of a receiving color vector and the center-of-gravity point of each color category of a receiving device, invention of this invention according to claim 3 can exchange color information so that reversal of a tint and discontinuity may not occur over the whole image.
[0035] Invention of this invention according to claim 4 the color category which shows the probability of occurrence of all the color categories of a dispatch device with the highest dispatch color vector It asks with the probability density function given by the standard normal distribution formed of the mean vector which the chrominance-signal data constellation classified into each color category has, and a distributed covariance vector. By determining the highest color category of the probability of occurrence as the color category to which the dispatch color vector concerned belongs, the color category to which a dispatch color vector belongs can be determined in a form with the versatility independent of the class and observation conditions of a device.
[0036] Invention of this invention according to claim 5 as physical relationship of a dispatch color vector and the center-of-gravity point of each color category of a dispatch device By using the normalization dispatch color distance which broke by the Mahalanobis distance from said all color category center-of-gravity points to each color category center-of-gravity point the Mahalanobis distance from all the color category center-of-gravity points given as an average of the center-of-gravity point of all color categories to a dispatch color vector A continuity is not broken down over the whole image but the mapping point of a receiving color vector can be determined, without generating reversal of gradation.
[0037] Invention of this invention according to claim 6 as physical relationship of a receiving color vector and the center-of-gravity point of each color category of a receiving device By using the normalization receiving color distance which broke by the Mahalanobis distance from said all color category center-of-gravity points to each color category center-of-gravity point the Mahalanobis distance from all the color category center-of-gravity points given as an average of the center-of-gravity point of all color categories to a receiving color vector A continuity is not broken down over the whole image but the mapping point of a receiving color vector can be determined, without generating reversal

of gradation.
[0038] Invention of this invention according to claim 7 divides into two or more color categories the color space which chrominance-signal data form about each showing the present condition voice showing the current property of a device that input-output behavioral characteristics change with change of an observation environment, and the original condition of this device of a former condition. By exchanging device property coordinating information between the same color categories, it sets to a single device. Between a former condition and present condition voice Color information can be exchanged so that the overall impressions of an image may not differ, and it has the operation which can make unique property adjustment of the single device from which input-output behavioral characteristics changed by physical fluctuation and physical degradation of a device, or change of observation conditions.
[0039] By selecting the present condition color vector out of the chrominance-signal data constellation of the present condition voice classified into the same color category as the color category to which the former condition color vector which is the color information which a former condition has belongs, invention of this invention according to claim 8 can exchange color information between the same color categories, and it can exchange color information so that the overall impressions of an image may not differ.
[0040] When the present condition color vector determines [the physical relationship which it has with the center-of-gravity point of each color category of a former condition] the present condition color vector so that it may be saved also in the center-of-gravity point of each color category of present condition voice, and the physical relationship which it has, as for invention of this invention according to claim 9, a former condition color vector can exchange color information so that reversal of a tint and discontinuity may not occur over the whole image.
[0041] Invention of this invention according to claim 10 the color category which shows the probability of occurrence of all the color categories of a former condition with the highest former condition color vector It asks with the probability density function given by the standard normal distribution formed of the mean vector which the chrominance-signal data constellation classified into each color category has, and a distributed covariance vector. By determining the highest color category of the probability of occurrence as the color category to which the former condition color vector concerned belongs, the color category to which a former condition color vector belongs can be determined in a form with the versatility independent of observation conditions.
[0042] Invention of this invention according to claim 11 as physical relationship of a former condition color vector and the center-of-gravity point of each color category of a former condition By using the normalizing agency condition color distance which broke by the Mahalanobis distance from said all color category center-of-gravity points to each color category center-of-gravity point the Mahalanobis distance from all the color category center-of-gravity points given as an average of the center-of-gravity point of all color categories to a former condition color vector A continuity is not broken down over the whole image but the mapping point of the present condition color vector can be determined, without generating reversal of gradation.
[0043] Invention of this invention according to claim 12 as physical relationship with the center-of-gravity point of each color category with the present condition color vector By using the normalization present condition color distance which broke by the Mahalanobis distance from said all color category center-of-gravity points to each color category center-of-gravity point the Mahalanobis distance from all the color category center-of-gravity points given as an average of the center-of-gravity point of all color categories to the present condition color vector A continuity is not broken down over the whole image but the mapping point of the present condition color vector can be determined, without generating reversal of gradation.
[0044] A color category invention of a publication to claims 13 and 16 of this invention White, black, red, Whether they are green, yellow, blue, purple, a peach, a sour orange, ashes, and tea, white, black red green yellow blue purple pink orange gray Since it is brown 11 fundamental color names which Berlin Kay found out and (bibliography: -- "BasicColor Terms. Their Universality and Evolution" --)

University ofCalifornia Press Berkley By using 1969, it has the operation which can perform the classification to a color category efficient without duplication.
[0045] Chrominance-signal data are the approach of being the output value from the input color or input device to an input device, an input value to an output device, or an output color from an output device, and invention given in claims 14 and 17 of this invention has the operation which can describe chrominance-signal data using a colorimetry value or a device signal.
[0046] Invention given in claims 15 and 18 of this invention is the approach an input color or an output color is CIELAB or CIELUV of uniform color space, and since CIELAB and CIELUV have human being's color difference sensory scales and a space scale in a color space in linear relation, they have the operation which improves the precision of color information interchange.
[0047] In the system for which the gestalt 1 of operation exchanges color information between devices (Gestalt 1 of operation) The color space which chrominance-signal data form for every dispatch device and receiving device is divided into two or more color categories by settlement of the color which an observer perceives. The probability density function which makes the population the chrominance-signal data constellation classified into the same color category is created. The color category to which said dispatch color vector belongs according to the probability of occurrence which the dispatch color vector which is the color information which said dispatch device disseminates generates from each color category is determined. Out of the chrominance-signal data constellation of the receiving device generated out of the same color category as the color category to which said dispatch color vector belongs Chrominance-signal data with which physical relationship with the center-of-gravity point of each color category of a receiving device becomes the closest to the physical relationship which said dispatch color vector has with the center-of-gravity point of each color category of a dispatch device are selected as a receiving color vector, and color information is exchanged. Hereafter, this color information-interchange approach is explained in full detail.
[0048] Drawing 1 shows the procedure at the time of displaying the image of the CRT display which is one of the operation gestalten of this invention on a liquid crystal display.
[0049] First, the color specification range of a CRT display and a liquid crystal display is explained. Drawing 2 (a) is an example of the color specification range (201) of a CRT display, and the color specification range (202) of a liquid crystal display. The data of a CRT display are based on the NTSC standard (red primary color;(x y) = (0. 67 0.33), green primary color;(x y) = (0. 21 0.71), blue primary color;(x y) = (0. 14 0.08)). The data of a liquid crystal display are "Nikkei electronics. It is based on no.570, P94 of 1992.12.21", and drawing 8 . The CRT display of the color specification range is larger, and when displaying the image of a CRT display on a liquid crystal display, color-gamut mapping is generally needed. Moreover, when the white points of both devices differ and it is adapted to the white of each device, the compatibility of a colorimetry value is not maintained but correspondence color prediction is needed. The concrete approach of this invention which solves these technical problems is explained.
[0050] Drawing 2 (b) piles up the color specification range of the device shown in the field of the color which Kelly showed at drawing 2 (a). The field of the color which Kelly showed has classified the color of all light regions into the color field of 23. If the part classified into "it is green" for example, on both displays is taken out from drawing 2 (b), it will become like drawing 3 (a). 301 shows the color specification range of a CRT display, and 302 shows the color specification range of a liquid crystal display. When the display rectangle of both displays is divided like drawing 3 (b) (303 is the same as that of 301.) If 304 being the same as that of 302 and color-gamut mapping are performed so that it may connect the black dots of both devices, white round heads, black square, and white square, the continuity of change of a tint will be maintained and natural correspondence relation will be materialized. This invention is performing mapping like drawing 3 (b) for every color fields of all, and has realized natural color-gamut mapping over the whole image. Hereafter, the mapping controlling method like drawing 3 (b) is explained in full detail.
[0051] Here, the color discrimination ellipse (bibliography; "basic [ ] of color dynamics" P137, Mitsuo Ikeda work) which MacAdam investigated to drawing 4 is shown. It expresses that all the colors in an

ellipse are visible to the same color with the color discrimination ellipse for which it asked by stimulus presentation whose standard source C (24 cd/m2) encloses a 2-degree bisection visual field (48 cds/m2) (however, in order to make a result legible, the magnitude of an ellipse is displayed by 10 times of an actual thing). It can be expected that the settlement of colors, such as "it is green", and "yellow green", "blueness green" which the settlement of a certain color, for example, Kelly, used, has elliptical from this result, respectively. And the boundary line of the color field for which Kelly asked can be interpreted as it being the intersection of each ellipse, as shown in drawing 5 . the ""settlement of a color by which 501 is perceived be "green" in drawing 5 -- expressing -- 502 -- "-- a settlement of the color perceived yellow green" -- expressing -- 503 -- "-- a settlement of the color perceived blueness green" -- expressing -- 504 -- it is green" -- "-- the boundary of the consciousness of yellow green" -- expressing -- 505 -- it is green" -- "-- expressing the boundary of the consciousness of blueness green", 506 expresses the color specification limitation of a CRT display.

[0052] Both this inventions classify the color space of a CRT display and a liquid crystal display into two or more color categories according to a perceived color from the above view, and a mapping point is determined only between the same color categories. Then, a perceived color must divide into two or more color category fields like the color field where kelly shown in drawing 2 (b) shows both the color spaces of a CRT display and a liquid crystal display first. And the approach needs the versatility independent of a class, observation conditions, etc. of a device. That is, the color field which kelly shows is as a result of a certain limited visual environment and an object, and must enable it to describe this on condition that arbitration.

[0053] Then, the representation color in a color space is shown to a test subject, the classification to two or more color categories is performed, and the probability density function which makes the population the chrominance-signal data constellation classified into the same color category is created. And the color category to which a dispatch color (CRT display) or a receiving color (liquid crystal display) belongs is taken as the color category which has the highest probability among the probabilities for a dispatch color or a receiving color to occur from each color category. A multidimensional normal distribution as shown in (several 2) is used for a probability density function. This is equivalent to the ellipse of a settlement of a color, and the result classified according to the probability of occurrence is equivalent to drawing of Kelly of drawing 2 (b).

[0054]

[Equation 2]

$$f(\mathbf{X})=\frac{1}{\left(\sqrt{2\pi}\right)^{P}\sqrt{|\Sigma|}}e^{-\frac{D^2}{2}} \qquad (2)$$

$$D^2=(\mathbf{X}-\mu)^t\Sigma^{-1}(\mathbf{X}-\mu)$$

Here, |sigma| expresses the determinant of the distributed covariance vector sigma, and sigma-1 expresses the inverse matrix of the distributed covariance vector sigma, respectively. D2 It is called the Mahalanobis distance and the distance from the center of gravity which considered the breadth of distribution is meant. P expresses a number of dimension. Although drawing 5 has explained on a two-dimensional flat surface, since a color space is the three-dimension space of (R, G, B), it is set to P= 3 with this operation gestalt. Moreover, a dispatch color vector expresses by (several 3), and X is [Equation 3].

$$\mathbf{X}=\begin{bmatrix}x_1 & x_2 & x_3\end{bmatrix}^t \qquad (3)$$

It is [Equation 4] when mean-vector mu is set to (several 4).

$$\boldsymbol{\mu}=\begin{bmatrix}\mu_1 & \mu_2 & \mu_3\end{bmatrix}^t \qquad (4)$$

The distributed covariance vector sigma is given by (several 5).

[Equation 5]

$$\Sigma = \begin{bmatrix} s_{11} & s_{12} & s_{13} \\ s_{21} & s_{22} & s_{23} \\ s_{31} & s_{32} & s_{33} \end{bmatrix}$$

$$= \begin{bmatrix} \frac{1}{n-1}\sum_{i=1}^{n}\left(x_{1_i}-\mu_1\right)^2 & \frac{1}{n-1}\sum_{i=1}^{n}\left(x_{1_i}-\mu_1\right)\left(x_{2_i}-\mu_2\right) & \frac{1}{n-1}\sum_{i=1}^{n}\left(x_{1_i}-\mu_1\right)\left(x_{3_i}-\mu_3\right) \\ \frac{1}{n-1}\sum_{i=1}^{n}\left(x_{2_i}-\mu_2\right)\left(x_{1_i}-\mu_1\right) & \frac{1}{n-1}\sum_{i=1}^{n}\left(x_{2_i}-\mu_2\right)^2 & \frac{1}{n-1}\sum_{i=1}^{n}\left(x_{2_i}-\mu_2\right)\left(x_{3_i}-\mu_3\right) \\ \frac{1}{n-1}\sum_{i=1}^{n}\left(x_{3_i}-\mu_3\right)\left(x_{1_i}-\mu_1\right) & \frac{1}{n-1}\sum_{i=1}^{n}\left(x_{3_i}-\mu_3\right)\left(x_{2_i}-\mu_2\right) & \frac{1}{n-1}\sum_{i=1}^{n}\left(x_{3_i}-\mu_3\right)^2 \end{bmatrix} \quad (5)$$

Here, n expresses the number of elements of a chrominance-signal data constellation. When (several 2) becomes max, since the Mahalanobis distance D2 serves as min, a dispatch color or a receiving color belongs to the color category from which the Mahalanobis distance D2 serves as min.
[0055] The test subject experiment which searches for mean-vector mu and the distributed covariance vector sigma is conducted like drawing 6 . Showing the color patch (602) of a test stimulus on a CRT display or a liquid crystal display (601), a test subject (603) looks at this and performs color naming using two or more fundamental color names (604 shows response actuation of inputting a test subject's response into a computer). The representation color which distributes and exists in the suitable location in a color space is used for a test stimulus. The conditions in a setup of this representation color are 1. All the set-up fundamental color names should appear from a test subject to a response.
2. In a color space, as much as possible, incline and choose a representation color that there is nothing. It is alike.
[0056] Next, in a fundamental color name, it is Berlin. and Eleven fundamental color names of the following which Kay found out are used (bibliography; "Basic Color Terms. Their Universality and Evolution" Univ. of California Press, Berkley, 1969).
[0057] 1. White(Shiro) 2. Black(Kuro) 3. Red(Aka) 4. Green(Midori) 5. Yellow (Ki) 6. Blue (Ao) 7. Purple(Murasaki) 8. pink(momo) 9. orange(daidai) 10. gray(hai) 11. A brown (cha) these 11 pieces fundamental color name 11 categories which investigated about 100 sorts of language, and were common with every language when it was the developed language -- it was drawn from there being a cull fundamental color name. Crawford summarized the definition of a fundamental color name as follows (bibliography; "Defining BASIC color terms", Anthropol Linguist, 24, 338-343, 1982).
[0058] 1. Be contained in all men's vocabulary.
2. When you use not being based on people, don't depend, but be stabilized and used.
3. The meaning should not be contained in other words.
4. Be used only for a specific object.
Moreover, Uchikawa drew the Japanese basic category color of 11 pieces (bibliography; "the category cull consciousness of a color, and storage", the 7th color dynamics conference, 1990).
[0059] Although 11 color categories are set up using the 11 above-mentioned fundamental color names with this operation gestalt from the above background, this invention is not restricted to this operation gestalt, and the setting approach of a color category is arbitrary.
[0060] As mentioned above, it classifies according to the probability density function in which 11 color categories have the color of a CRT display, and the color of a liquid crystal display, and color-gamut mapping is performed, maintaining relative location between the same color categories in the procedure shown in drawing 1 . Hereafter, color-gamut mapping is explained to a detail using drawing 1 .
[0061] The dispatch color vector C which is the color of a CRT display is expressed with (several 6) (101 of drawing 1).
[Equation 6]

$$\mathbf{C} = [r \quad g \quad b]^t \tag{6}$$

To which color category this dispatch color vector C belongs judges with 11 color categories belonging to the dispatch color vector C and the color category to which D2 [smallest] is given among the Mahalanobis distance D2 which it has. The chrominance-signal data constellation of the color category j formed of the response of the test subject who responds the perceived color of a representation color by 11 fundamental color names is expressed with (several 7).
[Equation 7]

$$\{r_{j_i},\ g_{j_i},\ b_{j_i} \mid i = 1,2,\ldots,n\} \tag{7}$$

Moreover, mean-vector alphaj of the color category j is set to (several 8).
[Equation 8]

$$\alpha = [\bar{r}_j \quad \bar{g}_j \quad \bar{b}_j]^t \tag{8}$$

Therefore, the distributed covariance vector Sj of the color category j is set to (several 5) to (several 9).
[Equation 9]

$$\mathbf{S}_j = \begin{bmatrix} s_{rr_j} & s_{rg_j} & s_{rb_j} \\ s_{gr_j} & s_{gg_j} & s_{gb_j} \\ s_{br_j} & s_{bg_j} & s_{bb_j} \end{bmatrix}$$

$$= \begin{bmatrix} \frac{1}{n-1}\sum_{i=1}^{n}(r_{j_i}-\bar{r}_j)^2 & \frac{1}{n-1}\sum_{i=1}^{n}(r_{j_i}-\bar{r}_j)(g_{j_i}-\bar{g}_j) & \frac{1}{n-1}\sum_{i=1}^{n}(r_{j_i}-\bar{r}_j)(b_{j_i}-\bar{b}_j) \\ \frac{1}{n-1}\sum_{i=1}^{n}(g_{j_i}-\bar{g}_j)(r_{j_i}-\bar{r}_j) & \frac{1}{n-1}\sum_{i=1}^{n}(g_{j_i}-\bar{g}_j)^2 & \frac{1}{n-1}\sum_{i=1}^{n}(g_{j_i}-\bar{g}_j)(b_{j_i}-\bar{b}_j) \\ \frac{1}{n-1}\sum_{i=1}^{n}(b_{j_i}-\bar{b}_j)(r_{j_i}-\bar{r}_j) & \frac{1}{n-1}\sum_{i=1}^{n}(b_{j_i}-\bar{b}_j)(g_{j_i}-\bar{g}_j) & \frac{1}{n-1}\sum_{i=1}^{n}(b_{j_i}-\bar{b}_j)^2 \end{bmatrix} \tag{9}$$

Mahalanobis distance D2 j of the color category j is given by (several 10) by the above.
[Equation 10]

$$D^2{}_j = [\mathbf{C} - \alpha_j]^t \mathbf{S}_j^{-1} [\mathbf{C} - \alpha_j]$$

$$= [r - \bar{r}_j \quad g - \bar{g}_j \quad b - \bar{b}_j] \begin{bmatrix} s_{rr_j} & s_{rg_j} & s_{rb_j} \\ s_{gr_j} & s_{gg_j} & s_{gb_j} \\ s_{br_j} & s_{bg_j} & s_{bb_j} \end{bmatrix} \begin{bmatrix} r - \bar{r}_j \\ g - \bar{g} \\ b - \bar{b}_j \end{bmatrix} \tag{10}$$

The color category Q which gives the minimum value among the Mahalanobis distance of 11 pieces acquired from (several 10) is detected (102 of drawing 1). Color data constellation Q' (103 of drawing 1) classified into the color category Q in the liquid crystal display becomes the candidate of a mapping point, and since this color category Q turns into a color category to which a dispatch color vector belongs, as shown in candidate color vector Q', a call, and (several 11), it expresses these.
[Equation 11]

$$Q'_k = [r_{q_k}{}' \quad g_{q_k}{}' \quad b_{q_k}{}']^t \qquad k = 1,2,\cdots,m \tag{11}$$

Here, m expresses the total of the color data classified into the color category Q of a liquid crystal display. When all the luminescent color colors of a liquid crystal display calculate the probability

generated from each color category, it asks for candidate color vector Q'. That is, the color data constellation from which the Mahalanobis distance of the color category Q becomes min among all the luminescent color colors of a liquid crystal display becomes candidate color vector Q'. Since candidate color vector Q' is chosen according to the color category to which a dispatch color vector belongs, it is necessary to put candidate color vector Q' in a database for every 11 color categories of a liquid crystal display beforehand.
[0062] As mentioned above, it is guaranteed by determining candidate color vector Q' of (several 11) that the consciousness category of the color displayed on a liquid crystal display becomes the same as that of CRT.
[0063] Next, the algorithm which extracts receiving color vector C' out of candidate color vector Q' is explained using drawing 7 and drawing 8 . It expresses with two-dimensional on account of declared.
[0064] The Ruhr at the time of mapping a dispatch color vector to a receiving color vector is as having been shown in drawing 3 (b), and maps the colors which are in agreement with category cull in the same color category field. for example, the black dot belonging to the green field (303) of the CRT display of drawing 3 (b) -- "green and yellow -- the color of a green boundary -- it is -- and -- among those, the category color" with the highest saturation -- cull description can be performed. such a category -- for aiming at mapping, maintaining cull implications -- a liquid crystal display -- setting -- "green and yellow -- the color of a green boundary -- it is -- and -- among those, color" with the highest saturation will be looked for. This is a black dot which belongs to the green field (304) of a liquid crystal display surely. the same -- both displays -- setting -- a black rectangular head -- "green and blueness -- the color of a green boundary -- it is -- and -- among those, color" with the highest saturation -- it is -- a white round head -- "green and yellow -- the color of a green boundary -- it is -- and -- among those, color" with the lowest saturation -- it is -- a white rectangular head -- "green and blueness -- the color of a green boundary -- it is -- and -- among those, saturation is lowest color" and they are the points which were in agreement with both category culls.
[0065] Thus, when it thinks, the point of having averaged four color data, a black dot, a black rectangular head, a white round head, and a white rectangular head, can be interpreted as in agreement with category cull among both displays. If the number of data is enough when four more color data are opened to all the color data constellations that constitute a color category, these averaged points can be interpreted as in agreement with category cull among both displays.
[0066] Then, as shown in drawing 7 , mean vector maps between the same color categories. the center of gravity given in drawing 7 as an average value of a color data constellation according to which Point G (701) was classified green in the CRT display -- expressing -- Point YG (702) -- a CRT display -- setting -- yellow -- the center of gravity given as an average value of a color data constellation according to which it was classified green -- expressing -- Point BG (703) -- a CRT display -- setting -- blueness -- the center of gravity given as an average value of a color data constellation according to which it was classified green is expressed. the center of gravity given on the other hand as an average value of a color data constellation according to which point G' (704) was classified green in the liquid crystal display -- expressing -- point YG' (705) -- a liquid crystal display -- setting -- yellow -- the center of gravity given as an average value of a color data constellation according to which it was classified green -- expressing -- point BG' (706) -- a liquid crystal display -- setting -- blueness -- the center of gravity given as an average value of a color data constellation according to which it was classified green is expressed. The center of gravity of 11 color categories is mapped among both displays as mentioned above.
[0067] Next, a center of gravity is considered to the pan of the center of gravity of three color categories of drawing 7 . Although drawing 8 (a) is the same as that of drawing 7 , Point O (801) is added to a CRT display, and point O' (802) is added to the liquid crystal display, respectively. Point O is the center of gravity of triangle G-YG-BG which the centers of gravity G, YG, and BG of three color categories of a CRT display form. the same -- a point -- O -- ' -- a liquid crystal display -- three -- a ** -- a color -- a category -- a center of gravity -- G -- ' -- YG -- ' -- BG -- ' -- forming -- a triangle -- G -- ' - YG -- ' - BG - - ' -- a center of gravity -- it is . It can be said that Point O and point O' also have the relation of mapping since three centers of gravity are points mapped by each among both displays as drawing 7 considered.

[0068] if the centers of gravity which are in the same color category among both devices are mapped wherever the location of the center of gravity of a dispatch device and a receiving device may be located like drawing 8 (b), although mapping between centers of gravity has been explained so far based on drawing 3 (b) -- a category -- cull relation can be saved. by the way -- although the point O (803) of drawing 8 (b) and point O' (804) are points mapped -- this time -- Segments LO, MO, and NO, L'O', M'O', and N'O -- ' -- die length -- a category -- it can be said that it has the same relation in the implications which form cull coincidence. therefore, a category -- in order to treat color-gamut mapping which saved cull relation, convenience is good when it normalizes in the distance from each color category connected to the point O of drawing 8 (b), and point O'.
[0069] The dispatch color C presupposes now that it generated in the location of Point O (803) temporarily. At this time, the dispatch color C and the distance of 11 color categories are expressed with (several 12).
[Equation 12]

$$D^2{}_{cj} = [C - \alpha_j]^t S_j^{-1} [C - \alpha_j] \qquad (12)$$

Here, D2Cj expresses the Mahalanobis distance from the center of gravity of the color category j to the dispatch color C. Moreover, it is [Equation 13] when distance of 11 color categories is set to (several 13) from Point O.

$$D^2{}_{oj} = [O - \alpha_j]^t S_j^{-1} [O - \alpha_j] \qquad (13)$$

Since the dispatch color C is on Point O (several 15) (several 14), it becomes.
[Equation 14]

$$D^2{}_{cj} = D^2{}_{oj} \qquad (14)$$

[Equation 15]

$$\frac{D^2{}_{cj}}{D^2{}_{oj}} = 1 \qquad (15)$$

And in a receiving device, it has the Mahalanobis distance as which the center of gravity of receiving color vector C' and 11 color categories is expressed in (several 16), and is [Equation 16].

$$D^2{}_{cj}' = [C' - \alpha_j']^t S_j'^{-1} [C' - \alpha_j'] \qquad (16)$$

It is [Equation 17] when point O' has the Mahalanobis distance expressed in (several 17) as the center of gravity of 11 color categories.

$$D^2{}_{oj}' = [O' - \alpha_j']^t S_j'^{-1} [O' - \alpha_j'] \qquad (17)$$

It is [(several 15) and] the same (several 18).
[Equation 18]

$$\frac{D^2{}_{cj}'}{D^2{}_{oj}'} = 1 \qquad (18)$$

In order to ******, receiving color vector C' needs to be the same as that of vector O'. therefore, receiving color C' -- point O' (804) -- being upwards is determined. All color category centers of gravity, and a call and its vector are called all color category mean vector here for the center of gravity of the center of gravity of Point O and 11 color categories like point O'. moreover (several 15) calls the distance which normalized the Mahalanobis distance (several 15) (**** -- D2 cj) from the center of gravity of a color category to a dispatch color in the Mahalanobis distance (several 15) (**** -- D2oj) from the center of gravity of the same color category to all color category centers of gravity

normalization dispatch color distance like. It is the same also at a receiving device.
[0070] It extends to the common case of drawing 8 (c) by the above view. It thinks by the left-hand side [of drawing 8 (c)], and dispatch device side first. Point P (805) is the location of a dispatch color, and the distance from the centers of gravity L, M, and N of three color categories is [Equation 19], respectively.

$$D^2{}_{PL} = [\mathbf{P} - \alpha_L]^t \mathbf{S}_j^{-1} [\mathbf{P} - \alpha_L] \tag{19}$$

[Equation 20]

$$D^2{}_{PM} = [\mathbf{P} - \alpha_M]^t \mathbf{S}_j^{-1} [\mathbf{P} - \alpha_M] \tag{20}$$

[Equation 21]

$$D^2{}_{PN} = [\mathbf{P} - \alpha_N]^t \mathbf{S}_j^{-1} [\mathbf{P} - \alpha_N] \tag{21}$$

It comes out. however, P -- a dispatch color vector and alphaL -- in the mean vector of the color category M, and alphaN, the inverse matrix of the distributed covariance matrix of the color category L and S-1M show the inverse matrix of the distributed covariance matrix of the color category M, and, as for the mean vector of the color category L, and alphaM, the mean vector of the color category N and S-1L show S-1 N of inverse matrices of the distributed covariance matrix of the color category N, respectively. The distance from the centers of gravity L, M, and N of three color categories to all the color category centers of gravity O is [Equation 22], respectively.

$$D^2{}_{OL} = [\mathbf{O} - \alpha_L]^t \mathbf{S}_j^{-1} [\mathbf{O} - \alpha_L] \tag{22}$$

[Equation 23]

$$D^2{}_{OM} = [\mathbf{O} - \alpha_M]^t \mathbf{S}_j^{-1} [\mathbf{O} - \alpha_M] \tag{23}$$

[Equation 24]

$$D^2{}_{ON} = [\mathbf{O} - \alpha_N]^t \mathbf{S}_j^{-1} [\mathbf{O} - \alpha_N] \tag{24}$$

It comes out. Therefore, the normalization dispatch color distance KPL of the point P of having seen from the color category L is [Equation 25].

$$K_{PL} = \frac{D^2{}_{PL}}{D^2{}_{OL}} \tag{25}$$

The normalization dispatch color distance KPM of the point P of having seen from the next door and the color category M is [Equation 26].

$$K_{PM} = \frac{D^2{}_{PM}}{D^2{}_{OM}} \tag{26}$$

The normalization dispatch color distance KPN of the point P of having seen from the next door and the color category N is [Equation 27].

$$K_{PN} = \frac{D^2{}_{PN}}{D^2{}_{ON}} \tag{27}$$

It becomes.
[0071] Next, a right-hand side [of drawing 8 (c)] and receiving device side is considered. Point P' (806) is the location of a receiving color, L' is the center of gravity of the same color category as the color category L of a dispatch device, M' is the center of gravity of the same color category as the color category M of a dispatch device, and N' is the center of gravity of the same color category as the color category N of a dispatch device. a point -- P -- ' -- L -- ' -- M -- ' -- N -- ' -- from -- distance --

respectively -- [Equation 28]

$$D^2{}_{PL}' = [\mathbf{P}'-\alpha_L']^t \mathbf{S}_j'^{-1} [\mathbf{P}'-\alpha_L'] \quad (28)$$

[Equation 29]

$$D^2{}_{PM}' = [\mathbf{P}'-\alpha_M']^t \mathbf{S}_j'^{-1} [\mathbf{P}'-\alpha_M'] \quad (29)$$

[Equation 30]

$$D^2{}_{PN}' = [\mathbf{P}'-\alpha_N']^t \mathbf{S}_j'^{-1} [\mathbf{P}'-\alpha_N'] \quad (30)$$

It comes out. However, for the mean vector of the color category N, and SL'-1, the inverse matrix of the distributed covariance matrix of the color category L and SM'-1 are [P' / a receiving color vector and alphaL' / the mean vector of the color category L, and alphaM' / the mean vector of the color category M, and alphaN'] the inverse matrix of the distributed covariance matrix of the color category M, and SN'. - 1 shows the inverse matrix of the distributed covariance matrix of the color category N, respectively. three -- a ** -- a color -- a category -- a center of gravity -- L -- ' -- M -- ' -- N -- ' -- from -- all -- a color -- a category -- a center of gravity -- O -- ' -- up to -- distance -- respectively -- [Equation 31]

$$D^2{}_{OL}' = [\mathbf{O}'-\alpha_L']^t \mathbf{S}_j'^{-1} [\mathbf{O}'-\alpha_L'] \quad (31)$$

[Equation 32]

$$D^2{}_{OM}' = [\mathbf{O}'-\alpha_M']^t \mathbf{S}_j'^{-1} [\mathbf{O}'-\alpha_M'] \quad (32)$$

[Equation 33]

$$D^2{}_{ON}' = [\mathbf{O}'-\alpha_N']^t \mathbf{S}_j'^{-1} [\mathbf{O}'-\alpha_N'] \quad (33)$$

It comes out. therefore, the normalization dispatch color distance KPL of point P' seen from center-of-gravity L' of the color category L -- ' -- [Equation 34]

$$K_{PL}' = \frac{D^2{}_{PL}'}{D^2{}_{OL}'} \quad (34)$$

Normalization dispatch color distance KPM' of Point P seen from the next door and the color category M is [Equation 35].

$$K_{PM}' = \frac{D^2{}_{PM}'}{D^2{}_{OM}'} \quad (35)$$

Normalization dispatch color distance KPN' of Point P seen from the next door and the color category N is [Equation 36].

$$K_{PN}' = \frac{D^2{}_{PN}'}{D^2{}_{ON}'} \quad (36)$$

It becomes.

[0072] now, it defined by drawing 8 (b) -- as -- a category -- formation of cull matching means coincidence of the normalization dispatch color distance which the same color category has, and normalization receiving color distance. Therefore, in the case of drawing 8 (c), a receiving color vector is about the color category L (several 37).

[Equation 37]

$$K_{PL} = K_{PL}' \quad (37)$$

About
 color category M (several 38)

[Equation 38]

$$K_{PM} = K_{PM}' \qquad (38)$$

About the color category N (several 39)
[Equation 39]

$$K_{PN} = K_{PN}' \qquad (39)$$

it will not become, if there is no ********.
[0073] Actuation in which the above extracts receiving color vector C' out of candidate color vector Q' is [Equation 40].

$$K_{cj} = K_{cj}' \qquad (40)$$

It is equivalent to discovering the color vector which can be filled with the smallest possible error out of candidate color vector Q' to all 11 color categories. Kcj expresses the normalization dispatch distance at the time of seeing the dispatch color vector C from the color category j here, and Kcj' expresses the normalization receiving distance at the time of seeing receiving color vector C' from the color category j. So, (several 41) is used for an error valuation plan.
[Equation 41]

$$E = \frac{K_{c1}'}{K_{c1}} \times \frac{K_{c2}'}{K_{c2}} \times \cdots\cdots \times \frac{K_{cj}'}{K_{cj}} \times \cdots\cdots \times \frac{K_{c11}'}{K_{c11}} \qquad (41)$$

However, it sets in the color category j (several 42).
[Equation 42]

$$\frac{K_{c1}'}{K_{c1}} < 1 \qquad (42)$$

It is [several 43] at the time of ******.

$$\frac{K_{c1}'}{K_{c1}} \qquad (43)$$

It replaces with ** (several 44).
[Equation 44]

$$\frac{K_{c1}}{K_{c1}'} \qquad (44)$$

The color vector which makes (several 41) min among candidate color vector Q' is made into receiving color vector C'.
[0074] In the above, the part which performs the algorithm which extracts candidate color vector Q' to receiving color vector C' is explained in drawing 1 . This actuation is divided into the following four processes.
All color category mean vector is computed in both a process 1. CRT display and a liquid crystal display (104 of drawing 1 , 105).
In a process 2. CRT display, normalization dispatch color distance (107 of drawing 1) is computed using the mean-vector [of the color category Q], distributed covariance vector (106 of drawing 1), and dispatch color vector (101 of drawing 1) all color category mean vector (104 of drawing 1).
In a process 3. liquid crystal display, normalization receiving color distance (109 of drawing 1) is computed using mean-vector [of the color category Q], distributed covariance vector (108 of drawing 1), and candidate color vector Q' (103 of drawing 1), and all color category mean vector (105 of drawing 1).
To each color category of 4.11 processes, normalization dispatch color distance is compared with normalization receiving color distance between a CRT display and a liquid crystal display (110 of drawing 1), the color vector to which the error of distance becomes small most is selected out of

candidate color vector Q', and this is made into drive signal C' of a liquid crystal display (111 of drawing 1).
[0075] Setting in a process 1, all color category mean-vector O of a CRT display is [Equation 45].

$$\mathbf{O} = \begin{bmatrix} \frac{\sum_{j=1}^{n} \bar{r}_j}{n} & \frac{\sum_{j=1}^{n} \bar{g}_j}{n} & \frac{\sum_{j=1}^{n} \bar{b}_j}{n} \end{bmatrix} \quad (45)$$

It is come out and given. n is the number of color categories and is n= 11 with this operation gestalt.
Moreover, all color category mean-vector O' of a liquid crystal display is [Equation 46].

$$\mathbf{O'} = \begin{bmatrix} \frac{\sum_{j=1}^{n} \bar{r}_j'}{n} & \frac{\sum_{j=1}^{n} \bar{g}_j'}{n} & \frac{\sum_{j=1}^{n} \bar{b}_j'}{n} \end{bmatrix} \quad (46)$$

It is come out and given. n is the number of color categories and is n= 11 with this operation gestalt.
[0076] Setting in a process 2, the normalization dispatch color distance Kcj is [Equation 47].

$$K_{cj} = \frac{D_{cj}}{D_{co}} \quad (47)$$

It is come out and given. Dcj expresses the Mahalanobis distance from the center of gravity of the color category seen from the color category j to the dispatch color C here, and Doj expresses the Mahalanobis distance from the center of gravity of the color category seen from the color category j to all color category centers of gravity.
[0077] Setting in a process 3, normalization receiving color distance Kcj' is [Equation 48].

$$K_{cj}' = \frac{D_{cj}'}{D_{co}'} \quad (48)$$

It is come out and given. Dcj' expresses the Mahalanobis distance from the center of gravity of the color category seen from the color category j to receiving color C' here, and Dco' expresses the Mahalanobis distance from the center of gravity of the color category seen from the color category j to all color category centers of gravity.
[0078] - (several 44) is used for error evaluation (several 41) of normalization dispatch color distance and normalization receiving color distance in a process 4.
[0079] as mentioned above, the color on a CRT display (r, g, b) is mapped by the color on a liquid crystal display monitor (r', g', and b -- '), these two pairs have the same color category, and since the relative location within a color category is the same, it can perform color-gamut mapping by the natural tint. Furthermore, the above-mentioned technique has the uniqueness which is not in the conventional technique, and the design of an image device and the color reproduction system of software and the color management in each user site can enforce it effectively.
[0080] In addition, it can be understood easily that it can use for correspondence color prediction if two color charts which observed the CRT display and the liquid crystal display under the environment where the sources of the illumination light differ, respectively are considered, and it can use for property adjustment of a device if a CRT display and a liquid crystal display are caught with the two properties of a single device that properties differed by aging etc.
[0081] Namely, when returning the current property of a single device that input-output behavioral characteristics changed with change of a condition to the original property, it sets. Present condition voice and the color space which chrominance-signal data form for every former condition are divided

into two or more color categories by settlement of the color which an observer perceives. The probability density function which makes the population the chrominance-signal data constellation classified into the same color category is created. The color category to which said former condition color vector belongs according to the probability of occurrence which the former condition color vector which is the color information which said former condition has generates from each color category is determined. out of the chrominance-signal data constellation of the present condition voice generated out of the same color category as the color category to which said former condition color vector belongs Chrominance-signal data with which physical relationship with the center-of-gravity point of each color category of present condition voice becomes the closest to the physical relationship which said former condition color vector has with the center-of-gravity point of each color category of a former condition are selected as a present condition color vector.
[0082] (Gestalt 2 of operation) The procedure which outputs the color of a CRT display to 4 color printer next is explained, using drawing 9 as a gestalt 2 of operation.
[0083] When changing the color (r, g, b) of a CRT display into the color (c, m, y, k) of 4 color printer, as shown in drawing 10 R> 0, it turns out that color-gamut mapping is needed from the difference in the color specification range of both devices. Drawing 10 is an example of the color specification range of the NTSC standard, and the color reproduction range of an ink jet printer, and is data which this invention person actually measured. Drawing 10 (a) is drawing which projected the colorimetry value of the representation color of a CRT display and an ink jet printer on the a*-b* flat surface of CIELAB space, drawing 10 (b) is drawing which projected the colorimetry value of the representation color of a CRT display and an ink jet printer on the L*-a* flat surface of CIELAB space, and drawing 10 (c) is drawing which projected the colorimetry value of the representation color of a CRT display and an ink jet printer on the L*-b* flat surface of CIELAB space.
[0084] Drawing 10 (a) In - (c), white rectangular heads are the primary color (C, M, Y) of an ink jet printer, a secondary color (C+M, M+Y, Y+C), and a gray representation color. Moreover, white trigonums are the primary color (R, G, B) of the CRT display in accordance with the NTSC standard, a secondary color (R+B, R+G, G+B), and a gray representation color. Furthermore, a sunspot is representation color 729 color of an ink jet printer, and is uniformly chosen from the whole color specification range of an ink jet printer. 1001 of drawing 10 expresses the appearance of the color specification range of a CRT display, and 1002 expresses the appearance of the color specification range of an ink jet printer.
[0085] Color-gamut mapping with this operation gestalt is mapping of three-dimension space and 4-dimensional space. Since number of dimensions differ, the approach used with "the gestalt 1 of operation" is inapplicable as it is. Then, it maps by dropping the number of dimension of a printer on a three dimension by the approach shown in drawing 11 . The representation color of a printer is first selected out of the inside of CMY three-dimension space (1101 of drawing 11). The selected color vector E serves as an element of the chrominance-signal data constellation of each color category, and it is used in order to describe the probability density function of a color category.
[0086] On the other hand, the color stimulus (1102 of drawing 11) shown to a test subject is [Equation 49] which performed Japanese ink generating and lower color removal (1103 of drawing 11) to the color vector E.

$$\mathbf{E}_p = \begin{bmatrix} c_p & m_p & y_p & k \end{bmatrix}^T$$
$$\begin{aligned} &\varepsilon = \min(c, m, y) - \rho \geq 0 \\ &c_P = c - \tau_c \varepsilon \\ &m_P = m - \tau_m \varepsilon \\ &y_P = y - \tau_y \varepsilon \\ &k = \phi \varepsilon \end{aligned} \qquad (49)$$

A printer is driven and created by the becoming color vector EP (1104 of drawing 11). Setting to (several 49), min (c, m, y) is c. m The function which detects the minimum value of y is expressed. rho, tauc, taum, and tauy and phi are arbitrary constants, respectively. It does not pass over (several 49) to an

example of Japanese ink generating and lower color removal, but it can apply the Japanese ink generating approach of arbitration, and the lower color removal approach to this invention.
[0087] Since a three dimension can describe the probability density function formed in printer space by the above actuation, the procedure of color-gamut mapping shown in drawing 9 is fundamentally [as drawing 1] the same. However, after receiving color vector C' can be found, as shown in 901 of drawing 9 , Japanese ink generating and lower color removal are performed. And Japanese ink generating of drawing 9 of 901 and lower color removal must be the same as that of 1103 of drawing 11 . 902 which is the output of 901 becomes a mapping point.
[0088] As mentioned above, he can understand color-gamut mapping, correspondence color prediction, and that device property adjustment can be performed further from the gestalt of this operation also by 4 color printer by which the color space and number of dimension of a CRT display differ from each other.
[0089] In addition, although the color information-interchange approach of of "the gestalt 1 of operation" and the "gestalt 2 of operation" and the adjustment approach of a device property were explained using the chrominance signal depending on devices, such as RGB and CMYK, the same operation gestalt can be performed by modeling the relation between a device signal and a colorimetry value also in colorimetry value space. For example, at the NTSC standard, it is [Equation 50].

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0.6067 & 0.1736 & 0.2001 \\ 0.2988 & 0.5868 & 0.1144 \\ 0.0000 & 0.0661 & 1.1150 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \qquad (50)$$

[Equation 51]

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1.9106 & -0.5326 & -0.2883 \\ -0.9843 & 1.9984 & -0.0283 \\ 0.0584 & -0.1185 & 0.8985 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix} \qquad (51)$$

Conversion of an RGB code and XYZ tristimulus values is possible in be alike. With input devices, such as a camera, the incorporated RGB code can be changed into XYZ tristimulus values by (several 50), and it can change into the XYZ tristimulus values of the color displayed by (several 51) by the driven RGB code with output equipment, such as a CRT display. If convertible for XYZ tristimulus values, since it is convertible for other colorimetry value space, such as CIELAB and CIELUV, it can be understood easily that a color space can be chosen as arbitration. It asks for the function which connects a device signal and a colorimetry value as shown in (several 50) and (several 51), and also all conversion information is formed into a direct table, or conversion information is searched for from representation color data, and if the relation between a device signal and a colorimetry value is decided in the form of compensating all conversion information by the interpolation operation, color information interchange and adjustment of a device property can be performed in colorimetry value space.
[0090] In addition, as compared with mapping according mapping by this operation gestalt 1 or device signal like 2 to a colorimetry value, it turns out that it has this operation gestalt 1 and the description that a colorimetry activity is not required of 2.
[0091]
[Effect of the Invention] According to this invention, it can opt for color-gamut mapping with the uniqueness which is not in the conventional technique as mentioned above. And the outstanding color information-interchange approach that improvement in the color reproduction nature of the image between the devices with which observation conditions differ etc. is realizable is realizable.
[0092] Moreover, according to this invention, the outstanding device property adjustment approach that improvement in the color reproduction nature of the image with which the adjustment approach of a device property can be determined with the uniqueness which is not in the conventional technique, and observation conditions differ etc. is realizable is realizable.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention is a technique about the color reproduction and color adjustment which can be used for all input image devices, such as a camera, a scanner, a monitor, and a printer, or an output image device.
[0002]
[Description of the Prior Art] Colorization of all image devices progresses in recent years, and the opportunity for office use or a home youth to also use a color image and a color document has increased. In connection with this, the color reproduction technique of each device simple substance also shows development, and high-performance-izing is remarkable.
[0003] however, fusion of the color reproduction which the open system appeared and has grown with the device of former each from the advance of a network technique and the increment in social use, and a color tone ready technique -- a degree -- it has risen to surface as a technical problem. For example, the NTSC signal has so far been used only for the color signal transduction of a broadcasting mold. In this case, management of a color is enough made by specification by the side which receives color information, and only the broadcasting station of an origination side should carry out a color management. However, the color signal transduction of a bidirectional mold must be used according to construction of the network infrastructure of a high bandwidth mold, each home and each office must become information dispatch origin, and the color management which the broadcasting station which has a know how has so far performed must be realized to some extent also in each home and each office. Information, for example, a photograph etc., to specifically send must be changed into the NTSC signal, without the addresser itself degrading color reproduction nature. Furthermore, not only the conversion to an NTSC signal but color information interchange with an open system needs interconnect of all chrominance signals.
[0004] "A difference in the color reproduction range between each device" and "a difference in an observation environment" are raised as a big technical problem among the problems of the color reproduction resulting from opening-ization of such color communication, and color adjustment.
[0005] "A difference in the color reproduction range between each device" is explained first. Generally, compared with printed matter, the color reproduction range of a CRT display is wide, and it can display a vivid color. Then, the problem that the color which the designer meant cannot express by the printing lifter occurs to print CG (Computer Graphic) image by the printer. On the other hand, when it excels in an umbra, i.e., a part with low brightness, at gradation nature compared with CRT and the picture of printed matter is displayed on CRT, a problem generates printed matter to the expression nature of the detail of the shadow section. The problem of the difference in the color reproduction range between such each device is fundamentally unsolvable from the limitation that a certain device cannot present a color physically. However, in the open system mentioned above, any constraint cannot be found and the exchange of color information is performed between each device. Therefore, a certain measures must be taken in the form where degradation of color reproduction nature is suppressed to the minimum. For this

reason, as for "color-gamut mapping" which maps the color exceeding the color reproduction range of the device of a receiving side in color reproduction within the limits, ED is furthered briskly in recent years.
[0006] There is an approach indicated by one of them at "color-gamut compression (II) in CG image" (color forum JAPAN' collection [of 96 summaries] P21- P24). This is [Equation 1].

$$\Delta E = \sqrt{\left(\frac{L^*_1 - L^*_2}{K_l}\right)^2 + \left(\frac{C^*_1 - C^*_2}{K_c}\right)^2 + \left(\frac{H^*_1 - H^*_2}{K_h}\right)^2} \quad (1)$$

It is the approach of performing color-gamut mapping by chrominance-signal pair from which the becoming color difference type is defined and this color difference becomes the minimum. (several 1) -- setting (L*1, H*1, C*1) -- it is the colorimetry value of the color which CG image on a monitor has, and color difference **E becomes min for color-gamut mapping -- as (L*2, H*2, C*2) -- it is determining within the color reproduction of a printer. It is Kc, when several sets of (kl, Kh(s), Kc(s)) were set up, the conditions of mapping were changed and the comparison of a subject-copy image and a reappearance image was performed. >= Kh >= When it sets up with Kl, it is reported that desirable color-gamut mapping was subjectively realizable. Kc >= Kh >= The mapping approach which becomes Kl will become the expression of "compressing in the saturation direction while fixing lightness if possible and also changing a hue to some extent", if the text of bibliography is quoted as it is.
[0007] Moreover, "Nikkei electronics As shown in drawing 12 , lightness and a hue are kept constant at no.570 and P101 of 1992.12.21", only saturation is adjusted, and the approach of mapping in the rim of the color reproduction range, the method of compressing all points smoothly aiming at the center-of-gravity section of a color space, avoiding a saturation fall, and determining a mapping point, as shown in drawing 13 , etc. are shown.
[0008] As mentioned above, in case all the introduced conventional approaches determine the mapping direction, they are observing the degree of preservation of the three attributes of color of the color of lightness, a hue, and saturation. Since the image which has the color completely same between each device fundamentally is unreproducible, if priority is given to preservation of which attribute, or if priority is given to degradation of which attribute, the approach of mapping will be determined from the decision criterion whether the impression of the appearance of a reappearance image becomes better. In the case of drawing 12 , weight is set to preservation of lightness and a hue, and it sacrifices the fall of saturation for it. Therefore, in the above and the conventional example, the multi-statement of the amount of adjustments of the attribute of three colors is carried out altogether, a reappearance image is created in the total combination, and the procedure of adopting the amount of adjustments of the three attributes of color most used for the high reappearance image of subjectivity evaluation as the mapping approach is taken.
[0009] Next, "a difference in an observation environment" is explained. The colorimetry system which Commission Internationale de I'Eclariage CIE defines is effectively utilized in the design of a color reproduction system. If the colorimetry value of two colors is in agreement, it can be judged that the two colors are the same. However, two colorimetry values which all the colorimetry systems that CIE advised fixed lighting conditions, and the bottom of different lighting was shown are incomparable the place by the present. For example, a colorimetry value cannot estimate the comparison of the color of the reappearance image compared with the subject-copy image compared with the fluorescent lamp, and the incandescent lamp.
[0010] However, it is very difficult for the completely same lighting condition and the "observation environment" which consists of a condition, observation distance, etc. of a background of an observation image further to find out the completely same scene in everyday life. Since the amounts of light reflected on the surface of a display differ in them when the same CG image is observed to daytime and late at night on the same display, even if the fluorescent substance independent luminescence property of a display is fixed, contrast completely differs from a tint etc. and it is visible to them. The input-output behavioral characteristics of a monitor also including the effect of outdoor daylight changed. Moreover,

the color information interchange between the remote places through a network is a case which the need of controlling a color between observation environments which divide and are different produces. When the sources of the illumination light differ by the addresser and addressee side, generally the pair of the color perceived by the same color among both is called a "correspondence color." And when the color by the side of an addresser is illuminated in the source of the illumination light by the side of an addressee, it calls it "correspondence color prediction" to predict whether it is visible to what kind of color. Change of the input-output behavioral characteristics of the single device by change of an observation environment is also one gestalt of correspondence color prediction.

[0011] This correspondence color prediction is described by change of the adaptation condition of a visual system over lighting ("color dynamics" (Ota ** work) Tokyo Denki University Press (1993) P184 - P191). von Kries proposed the "adaptation equation" noting that the tristimulus values of a perceived color changed to the ratio of the tristimulus values which the source of the illumination light has at linearity. Moreover, Naya applies illuminance level and the reflection factor of a background to the parameter of an adaptation equation, and is the Kherson Judd effectiveness (if a gray scale is illuminated with chromatic color light). bright gray -- the hue of the illumination light -- sensing -- dark gray -- the hue of the complementary color -- sensing -- the Sutee Bunce effectiveness (if an illuminance is changed and the group of an achromatic color is illuminated) And the gray more dark in white of bright gray is more visible to black in a high illuminance, it is the hunt effectiveness (if an illuminance is changed and a chromatic color is illuminated). With the adaptation equation of the nonlinear mold which can predict that it goes up and is visible according to an illuminance etc., the saturation (KARAFURUNESU) perceived is raising the precision of correspondence color prediction.

[0012]

[Problem(s) to be Solved by the Invention] However, it leaves some technical problems to the color-gamut mapping approach by the above-mentioned conventional approach, and correspondence color prediction.

[0013] First, since unique relation is not built between the amount of adjustments of a hue, saturation, and lightness, and color reproduction nature, if color-gamut mapping does not test all the amounts of adjustments that can be considered, the technical problem which cannot specify the best color reproduction image exists.

[0014] Moreover, correspondence color prediction is usable only under limited observation conditions, has a big gap to an actual use situation, and has the technical problem that practical level is not reached.

[0015] It aims at offering the color information-interchange approach and the device property adjustment approach of enabling practical correspondence color prediction which this invention solves the technical problem of the above-mentioned conventional technique, and can determine the approach of color-gamut mapping uniquely, and absorbs the difference among observation conditions.

[0016]

[Means for Solving the Problem] In color-gamut mapping, since the same color cannot be fundamentally shown between each device, it becomes a target to exchange color information so that the overall impressions of the image in each device may not differ as much as possible. For example, if it expresses by the tint, as for "a red flower", a printing lifter should also be "a red flower" on CRT, and it is not desirable that the categories of the color which a flower has like "a yellow flower" and "an orange flower" differ. Furthermore, a way with the red of a flower "more powerful than the red of an apple" when it is "stronger [the red of a flower] than the red of an apple" on CRT is desirable, and it is not desirable when "the red of a flower is weaker than the red of an apple". [a printing lifter]

[0017] Thus, in order to make it the overall impressions of an image not differ as much as possible in color-gamut mapping, it is important that reversal of a tint and discontinuity do not occur between each device over the whole (b) image with the same color category of (a) same pixel.

[0018] So, in this invention, it divides into two or more color categories by settlement of the color which an observer perceives the color space which chrominance-signal data form for every dispatch device and receiving device, and color information is exchanged only between the same color categories.

[0019] That is, the drive signal in the receiving device of the pixel perceived "red" with the dispatch

device is selected from the chrominance-signal data constellations perceived "red" on a receiving device.

[0020] Moreover, in order to determine a receiving color vector from the inside of the same color category, a dispatch color vector determines this invention as the center-of-gravity point of all the color categories in a dispatch device color space according to the relative physical relationship which it has.
[0021] For example, when the center of gravity of near and the "green" color category which is the "red" complementary color is further from the center of gravity of the color category of "Orange" where the location with the dispatch color vector perceived "red" resembled "red", the chrominance-signal data near "Orange" should be chosen as the receiving color vector from "it is green." And when the distance of a dispatch color vector and the center of gravity of "Orange" is 1/2 of the distance of a dispatch color vector and a "green" center of gravity in the color space of a dispatch device, the receiving color vector of the center of gravity of "Orange" and the distance which it has chosen in receiving device space should be 1/2 of distance with a "green" center of gravity.
[0022] Thus, reversal of a tint and color information interchange which discontinuity" does not generate are realizable over the whole "image by selecting the receiving color vector for every pixel so that the relative location of the distance which a dispatch color vector has with the center of gravity of each color category may be materialized also in the color space of a receiving device.
[0023] Moreover, in this invention, the modeling of the color category is carried out according to a standard normal distribution. An observer searches for the mean vector and a distributed covariance vector by two or more chrominance-signal data constellations classified into each color category in consciousness, defines a standard normal distribution for every category, and makes this the probability of occurrence of the color vector from each color category. And the color category of a certain pixel is taken as a color category with the highest probability among the probability of occurrence which each color category has.
[0024] Moreover, the distance in which a dispatch color vector has this invention with the center of gravity of each color category, and a receiving color vector use the center of gravity of each color category, and the Mahalanobis distance asked also for the distance which it has from a mean vector and a distributed covariance vector.
[0025] A dispatch chrominance signal searches for all the color category center-of-gravity points given as an average of the center-of-gravity point of all color categories, and describes the center-of-gravity point of each color category, and the relative location which it has in the normalization dispatch color distance which broke the Mahalanobis distance from all color category center-of-gravity points to a dispatch color vector by the Mahalanobis distance from said all color category center-of-gravity points to each color category center-of-gravity point.
[0026] A receiving chrominance signal searches for all the color category center-of-gravity points given as an average of the center-of-gravity point of all color categories, and describes the center-of-gravity point of each color category, and the relative location which it has in the normalization receiving color distance which broke the Mahalanobis distance from all color category center-of-gravity points to a receiving color vector by the Mahalanobis distance from said all color category center-of-gravity points to each color category center-of-gravity point.
[0027] It is determined that the mapping point of a receiving color vector will become equal to normalization dispatch color distance [as opposed to all color categories in the size relation of the normalization receiving color distance over all color categories].
[0028] As mentioned above, by carrying out the modeling of the color category by the standard normal distribution from an observer's response, the color category of the pixel of arbitration could determine this invention in the dispatch device and the receiving device, and when a receiving device side also maintains the relative location which the center-of-gravity point of a dispatch color vector and each color category has further, it has secured unrealizable "uniqueness" by the conventional color-gamut mapping method.
[0029] In addition, the color information-interchange approach is applicable also to correspondence color prediction. Although the conventional correspondence color prediction can be performed only

under the conditions on which observation environments, such as lighting, were controlled completely, this invention can perform correspondence color prediction under the observation environment of arbitration by classifying the color category by the observer.

[0030] Moreover, if a dispatch device and a receiving device replace that it is the former condition and present condition voice of the single device from which input-output behavioral characteristics changed, respectively, the above color information-interchange approach is applicable also to the device property adjustment approach.

[0031] As mentioned above, according to this invention, the approach of color-gamut mapping can be determined uniquely. And property adjustment of the single device from which input-output behavioral characteristics changed by improvement in the color reproduction nature of the image between the devices with which observation conditions differ, physical fluctuation and physical degradation of a device, or change of observation conditions etc. is realizable.

[0032]

[Embodiment of the Invention] By dividing into two or more color categories by settlement of the color which an observer perceives the color space which chrominance-signal data form for every dispatch device and receiving device, and exchanging color information between the same color categories, invention of this invention according to claim 1 can exchange color information so that the overall impressions of an image may not differ, and it can improve the color reproduction nature of an image.

[0033] By selecting a receiving color vector out of the chrominance-signal data constellation of the receiving device classified into the same color category as the color category to which the dispatch color vector of the color information which a dispatch device disseminates belongs, invention of this invention according to claim 2 can exchange color information between the same color categories, and it can exchange color information so that the overall impressions of an image may not differ.

[0034] By selecting a receiving color vector so that the physical relationship of a dispatch color vector and the center-of-gravity point of each color category of a dispatch device may be saved also in the physical relationship of a receiving color vector and the center-of-gravity point of each color category of a receiving device, invention of this invention according to claim 3 can exchange color information so that reversal of a tint and discontinuity may not occur over the whole image.

[0035] Invention of this invention according to claim 4 the color category which shows the probability of occurrence of all the color categories of a dispatch device with the highest dispatch color vector It asks with the probability density function given by the standard normal distribution formed of the mean vector which the chrominance-signal data constellation classified into each color category has, and a distributed covariance vector. By determining the highest color category of the probability of occurrence as the color category to which the dispatch color vector concerned belongs, the color category to which a dispatch color vector belongs can be determined in a form with the versatility independent of the class and observation conditions of a device.

[0036] Invention of this invention according to claim 5 as physical relationship of a dispatch color vector and the center-of-gravity point of each color category of a dispatch device By using the normalization dispatch color distance which broke by the Mahalanobis distance from said all color category center-of-gravity points to each color category center-of-gravity point the Mahalanobis distance from all the color category center-of-gravity points given as an average of the center-of-gravity point of all color categories to a dispatch color vector A continuity is not broken down over the whole image but the mapping point of a receiving color vector can be determined, without generating reversal of gradation.

[0037] Invention of this invention according to claim 6 as physical relationship of a receiving color vector and the center-of-gravity point of each color category of a receiving device By using the normalization receiving color distance which broke by the Mahalanobis distance from said all color category center-of-gravity points to each color category center-of-gravity point the Mahalanobis distance from all the color category center-of-gravity points given as an average of the center-of-gravity point of all color categories to a receiving color vector A continuity is not broken down over the whole image but the mapping point of a receiving color vector can be determined, without generating reversal

of gradation.
[0038] Invention of this invention according to claim 7 divides into two or more color categories the color space which chrominance-signal data form about each showing the present condition voice showing the current property of a device that input-output behavioral characteristics change with change of an observation environment, and the original condition of this device of a former condition. By exchanging device property coordinating information between the same color categories, it sets to a single device. Between a former condition and present condition voice Color information can be exchanged so that the overall impressions of an image may not differ, and it has the operation which can make unique property adjustment of the single device from which input-output behavioral characteristics changed by physical fluctuation and physical degradation of a device, or change of observation conditions.
[0039] By selecting the present condition color vector out of the chrominance-signal data constellation of the present condition voice classified into the same color category as the color category to which the former condition color vector which is the color information which a former condition has belongs, invention of this invention according to claim 8 can exchange color information between the same color categories, and it can exchange color information so that the overall impressions of an image may not differ.
[0040] When the present condition color vector determines [the physical relationship which it has with the center-of-gravity point of each color category of a former condition] the present condition color vector so that it may be saved also in the center-of-gravity point of each color category of present condition voice, and the physical relationship which it has, as for invention of this invention according to claim 9, a former condition color vector can exchange color information so that reversal of a tint and discontinuity may not occur over the whole image.
[0041] Invention of this invention according to claim 10 the color category which shows the probability of occurrence of all the color categories of a former condition with the highest former condition color vector It asks with the probability density function given by the standard normal distribution formed of the mean vector which the chrominance-signal data constellation classified into each color category has, and a distributed covariance vector. By determining the highest color category of the probability of occurrence as the color category to which the former condition color vector concerned belongs, the color category to which a former condition color vector belongs can be determined in a form with the versatility independent of observation conditions.
[0042] Invention of this invention according to claim 11 as physical relationship of a former condition color vector and the center-of-gravity point of each color category of a former condition By using the normalizing agency condition color distance which broke by the Mahalanobis distance from said all color category center-of-gravity points to each color category center-of-gravity point the Mahalanobis distance from all the color category center-of-gravity points given as an average of the center-of-gravity point of all color categories to a former condition color vector A continuity is not broken down over the whole image but the mapping point of the present condition color vector can be determined, without generating reversal of gradation.
[0043] Invention of this invention according to claim 12 as physical relationship with the center-of-gravity point of each color category with the present condition color vector By using the normalization present condition color distance which broke by the Mahalanobis distance from said all color category center-of-gravity points to each color category center-of-gravity point the Mahalanobis distance from all the color category center-of-gravity points given as an average of the center-of-gravity point of all color categories to the present condition color vector A continuity is not broken down over the whole image but the mapping point of the present condition color vector can be determined, without generating reversal of gradation.
[0044] A color category invention of a publication to claims 13 and 16 of this invention White, black, red, Whether they are green, yellow, blue, purple, a peach, a sour orange, ashes, and tea, white, black red green yellow blue purple pink orange gray Since it is brown 11 fundamental color names which Berlin Kay found out and (bibliography: -- "BasicColor Terms. Their Universality and Evolution" --)

University ofCalifornia Press Berkley By using 1969, it has the operation which can perform the classification to a color category efficient without duplication.
[0045] Chrominance-signal data are the approach of being the output value from the input color or input device to an input device, an input value to an output device, or an output color from an output device, and invention given in claims 14 and 17 of this invention has the operation which can describe chrominance-signal data using a colorimetry value or a device signal.
[0046] Invention given in claims 15 and 18 of this invention is the approach an input color or an output color is CIELAB or CIELUV of uniform color space, and since CIELAB and CIELUV have human being's color difference sensory scales and a space scale in a color space in linear relation, they have the operation which improves the precision of color information interchange.
[0047] In the system for which the gestalt 1 of operation exchanges color information between devices (Gestalt 1 of operation) The color space which chrominance-signal data form for every dispatch device and receiving device is divided into two or more color categories by settlement of the color which an observer perceives. The probability density function which makes the population the chrominance-signal data constellation classified into the same color category is created. The color category to which said dispatch color vector belongs according to the probability of occurrence which the dispatch color vector which is the color information which said dispatch device disseminates generates from each color category is determined. Out of the chrominance-signal data constellation of the receiving device generated out of the same color category as the color category to which said dispatch color vector belongs Chrominance-signal data with which physical relationship with the center-of-gravity point of each color category of a receiving device becomes the closest to the physical relationship which said dispatch color vector has with the center-of-gravity point of each color category of a dispatch device are selected as a receiving color vector, and color information is exchanged. Hereafter, this color information-interchange approach is explained in full detail.
[0048] Drawing 1 shows the procedure at the time of displaying the image of the CRT display which is one of the operation gestalten of this invention on a liquid crystal display.
[0049] First, the color specification range of a CRT display and a liquid crystal display is explained. Drawing 2 (a) is an example of the color specification range (201) of a CRT display, and the color specification range (202) of a liquid crystal display. The data of a CRT display are based on the NTSC standard (red primary color;(x y) = (0. 67 0.33), green primary color;(x y) = (0. 21 0.71), blue primary color;(x y) = (0. 14 0.08)). The data of a liquid crystal display are "Nikkei electronics. It is based on no.570, P94 of 1992.12.21", and drawing 8 . The CRT display of the color specification range is larger, and when displaying the image of a CRT display on a liquid crystal display, color-gamut mapping is generally needed. Moreover, when the white points of both devices differ and it is adapted to the white of each device, the compatibility of a colorimetry value is not maintained but correspondence color prediction is needed. The concrete approach of this invention which solves these technical problems is explained.
[0050] Drawing 2 (b) piles up the color specification range of the device shown in the field of the color which Kelly showed at drawing 2 (a). The field of the color which Kelly showed has classified the color of all light regions into the color field of 23. If the part classified into "it is green" for example, on both displays is taken out from drawing 2 (b), it will become like drawing 3 (a). 301 shows the color specification range of a CRT display, and 302 shows the color specification range of a liquid crystal display. When the display rectangle of both displays is divided like drawing 3 (b) (303 is the same as that of 301.) If 304 being the same as that of 302 and color-gamut mapping are performed so that it may connect the black dots of both devices, white round heads, black square, and white square, the continuity of change of a tint will be maintained and natural correspondence relation will be materialized. This invention is performing mapping like drawing 3 (b) for every color fields of all, and has realized natural color-gamut mapping over the whole image. Hereafter, the mapping controlling method like drawing 3 (b) is explained in full detail.
[0051] Here, the color discrimination ellipse (bibliography; "basic [ ] of color dynamics" P137, Mitsuo Ikeda work) which MacAdam investigated to drawing 4 is shown. It expresses that all the colors in an

ellipse are visible to the same color with the color discrimination ellipse for which it asked by stimulus presentation whose standard source C (24 cd/m2) encloses a 2-degree bisection visual field (48 cds/m2) (however, in order to make a result legible, the magnitude of an ellipse is displayed by 10 times of an actual thing). It can be expected that the settlement of colors, such as "it is green", and "yellow green", "blueness green" which the settlement of a certain color, for example, Kelly, used, has elliptical from this result, respectively. And the boundary line of the color field for which Kelly asked can be interpreted as it being the intersection of each ellipse, as shown in drawing 5 . the ""settlement of a color by which 501 is perceived be "green" in drawing 5 -- expressing -- 502 -- "-- a settlement of the color perceived yellow green" -- expressing -- 503 -- "-- a settlement of the color perceived blueness green" -- expressing -- 504 -- it is green" -- "-- the boundary of the consciousness of yellow green" -- expressing -- 505 -- it is green" -- "-- expressing the boundary of the consciousness of blueness green", 506 expresses the color specification limitation of a CRT display.
[0052] Both this inventions classify the color space of a CRT display and a liquid crystal display into two or more color categories according to a perceived color from the above view, and a mapping point is determined only between the same color categories. Then, a perceived color must divide into two or more color category fields like the color field where kelly shown in drawing 2 (b) shows both the color spaces of a CRT display and a liquid crystal display first. And the approach needs the versatility independent of a class, observation conditions, etc. of a device. That is, the color field which kelly shows is as a result of a certain limited visual environment and an object, and must enable it to describe this on condition that arbitration.
[0053] Then, the representation color in a color space is shown to a test subject, the classification to two or more color categories is performed, and the probability density function which makes the population the chrominance-signal data constellation classified into the same color category is created. And the color category to which a dispatch color (CRT display) or a receiving color (liquid crystal display) belongs is taken as the color category which has the highest probability among the probabilities for a dispatch color or a receiving color to occur from each color category. A multidimensional normal distribution as shown in (several 2) is used for a probability density function. This is equivalent to the ellipse of a settlement of a color, and the result classified according to the probability of occurrence is equivalent to drawing of Kelly of drawing 2 (b).
[0054]
[Equation 2]

$$f(\mathbf{X}) = \frac{1}{\left(\sqrt{2\pi}\right)^{P}\sqrt{|\Sigma|}} e^{-\frac{D^2}{2}} \qquad (2)$$
$$D^2 = (\mathbf{X}-\mu)^t \Sigma^{-1} (\mathbf{X}-\mu)$$

Here, |sigma| expresses the determinant of the distributed covariance vector sigma, and sigma-1 expresses the inverse matrix of the distributed covariance vector sigma, respectively. D2 It is called the Mahalanobis distance and the distance from the center of gravity which considered the breadth of distribution is meant. P expresses a number of dimension. Although drawing 5 has explained on a two-dimensional flat surface, since a color space is the three-dimension space of (R, G, B), it is set to P= 3 with this operation gestalt. Moreover, a dispatch color vector expresses by (several 3), and X is [Equation 3].

$$\mathbf{X} = [x_1 \;\; x_2 \;\; x_3]^t \qquad (3)$$

It is [Equation 4] when mean-vector mu is set to (several 4).

$$\boldsymbol{\mu} = [\mu_1 \;\; \mu_2 \;\; \mu_3]^t \qquad (4)$$

The distributed covariance vector sigma is given by (several 5).
[Equation 5]

$$\Sigma = \begin{bmatrix} s_{11} & s_{12} & s_{13} \\ s_{21} & s_{22} & s_{23} \\ s_{31} & s_{32} & s_{33} \end{bmatrix} = \begin{bmatrix} \frac{1}{n-1}\sum_{i=1}^{n}\left(x_{1_i}-\mu_1\right)^2 & \frac{1}{n-1}\sum_{i=1}^{n}\left(x_{1_i}-\mu_1\right)\left(x_{2_i}-\mu_2\right) & \frac{1}{n-1}\sum_{i=1}^{n}\left(x_{1_i}-\mu_1\right)\left(x_{3_i}-\mu_3\right) \\ \frac{1}{n-1}\sum_{i=1}^{n}\left(x_{2_i}-\mu_2\right)\left(x_{1_i}-\mu_1\right) & \frac{1}{n-1}\sum_{i=1}^{n}\left(x_{2_i}-\mu_2\right)^2 & \frac{1}{n-1}\sum_{i=1}^{n}\left(x_{2_i}-\mu_2\right)\left(x_{3_i}-\mu_3\right) \\ \frac{1}{n-1}\sum_{i=1}^{n}\left(x_{3_i}-\mu_3\right)\left(x_{1_i}-\mu_1\right) & \frac{1}{n-1}\sum_{i=1}^{n}\left(x_{3_i}-\mu_3\right)\left(x_{2_i}-\mu_2\right) & \frac{1}{n-1}\sum_{i=1}^{n}\left(x_{3_i}-\mu_3\right)^2 \end{bmatrix} \quad (5)$$

Here, n expresses the number of elements of a chrominance-signal data constellation. When (several 2) becomes max, since the Mahalanobis distance D2 serves as min, a dispatch color or a receiving color belongs to the color category from which the Mahalanobis distance D2 serves as min.
[0055] The test subject experiment which searches for mean-vector mu and the distributed covariance vector sigma is conducted like drawing 6 . Showing the color patch (602) of a test stimulus on a CRT display or a liquid crystal display (601), a test subject (603) looks at this and performs color naming using two or more fundamental color names (604 shows response actuation of inputting a test subject's response into a computer). The representation color which distributes and exists in the suitable location in a color space is used for a test stimulus. The conditions in a setup of this representation color are 1. All the set-up fundamental color names should appear from a test subject to a response.
2. In a color space, as much as possible, incline and choose a representation color that there is nothing. It is alike.
[0056] Next, in a fundamental color name, it is Berlin. and Eleven fundamental color names of the following which Kay found out are used (bibliography; "Basic Color Terms. Their Universality and Evolution" Univ. of California Press, Berkley, 1969).
[0057] 1. White(Shiro) 2. Black(Kuro) 3. Red(Aka) 4. Green(Midori) 5. Yellow (Ki) 6. Blue (Ao) 7. Purple(Murasaki) 8. pink(momo) 9. orange(daidai) 10. gray(hai) 11. A brown (cha) these 11 pieces fundamental color name 11 categories which investigated about 100 sorts of language, and were common with every language when it was the developed language -- it was drawn from there being a cull fundamental color name. Crawford summarized the definition of a fundamental color name as follows (bibliography; "Defining BASIC color terms", Anthropol Linguist, 24, 338-343, 1982).
[0058] 1. Be contained in all men's vocabulary.
2. When you use not being based on people, don't depend, but be stabilized and used.
3. The meaning should not be contained in other words.
4. Be used only for a specific object.
Moreover, Uchikawa drew the Japanese basic category color of 11 pieces (bibliography; "the category cull consciousness of a color, and storage", the 7th color dynamics conference, 1990).
[0059] Although 11 color categories are set up using the 11 above-mentioned fundamental color names with this operation gestalt from the above background, this invention is not restricted to this operation gestalt, and the setting approach of a color category is arbitrary.
[0060] As mentioned above, it classifies according to the probability density function in which 11 color categories have the color of a CRT display, and the color of a liquid crystal display, and color-gamut mapping is performed, maintaining relative location between the same color categories in the procedure shown in drawing 1 . Hereafter, color-gamut mapping is explained to a detail using drawing 1 .
[0061] The dispatch color vector C which is the color of a CRT display is expressed with (several 6) (101 of drawing 1).
[Equation 6]

$$\mathbf{C} = [r \quad g \quad b]^t \qquad (6)$$

To which color category this dispatch color vector C belongs judges with 11 color categories belonging to the dispatch color vector C and the color category to which D2 [smallest] is given among the Mahalanobis distance D2 which it has. The chrominance-signal data constellation of the color category j formed of the response of the test subject who responds the perceived color of a representation color by 11 fundamental color names is expressed with (several 7).
[Equation 7]

$$\{r_{j_i},\ g_{j_i},\ b_{j_i} \mid i = 1,2,\ldots,n\} \qquad (7)$$

Moreover, mean-vector alphaj of the color category j is set to (several 8).
[Equation 8]

$$\alpha = [\bar{r}_j \quad \bar{g}_j \quad \bar{b}_j]^t \qquad (8)$$

Therefore, the distributed covariance vector Sj of the color category j is set to (several 5) to (several 9).
[Equation 9]

$$\mathbf{S}_j = \begin{bmatrix} s_{rr_j} & s_{rg_j} & s_{rb_j} \\ s_{gr_j} & s_{gg_j} & s_{gb_j} \\ s_{br_j} & s_{bg_j} & s_{bb_j} \end{bmatrix}$$

$$= \begin{bmatrix} \frac{1}{n-1}\sum_{i=1}^{n}(r_{j_i} - \bar{r}_j)^2 & \frac{1}{n-1}\sum_{i=1}^{n}(r_{j_i} - \bar{r}_j)(g_{j_i} - \bar{g}_j) & \frac{1}{n-1}\sum_{i=1}^{n}(r_{j_i} - \bar{r}_j)(b_{j_i} - \bar{b}_j) \\ \frac{1}{n-1}\sum_{i=1}^{n}(g_{j_i} - \bar{g}_j)(r_{j_i} - \bar{r}_j) & \frac{1}{n-1}\sum_{i=1}^{n}(g_{j_i} - \bar{g}_j)^2 & \frac{1}{n-1}\sum_{i=1}^{n}(g_{j_i} - \bar{g}_j)(b_{j_i} - \bar{b}_j) \\ \frac{1}{n-1}\sum_{i=1}^{n}(b_{j_i} - \bar{b}_j)(r_{j_i} - \bar{r}_j) & \frac{1}{n-1}\sum_{i=1}^{n}(b_{j_i} - \bar{b}_j)(g_{j_i} - \bar{g}_j) & \frac{1}{n-1}\sum_{i=1}^{n}(b_{j_i} - \bar{b}_j)^2 \end{bmatrix} \qquad (9)$$

Mahalanobis distance D2 j of the color category j is given by (several 10) by the above.
[Equation 10]

$$D^2{}_j = [\mathbf{C} - \alpha_j]^t \mathbf{S}_j^{-1} [\mathbf{C} - \alpha_j]$$

$$= [r - \bar{r}_j \quad g - \bar{g}_j \quad b - \bar{b}_j] \begin{bmatrix} s_{rr_j} & s_{rg_j} & s_{rb_j} \\ s_{gr_j} & s_{gg_j} & s_{gb_j} \\ s_{br_j} & s_{bg_j} & s_{bb_j} \end{bmatrix} \begin{bmatrix} r - \bar{r}_j \\ g - \bar{g} \\ b - \bar{b}_j \end{bmatrix} \qquad (10)$$

The color category Q which gives the minimum value among the Mahalanobis distance of 11 pieces acquired from (several 10) is detected (102 of drawing 1). Color data constellation Q' (103 of drawing 1) classified into the color category Q in the liquid crystal display becomes the candidate of a mapping point, and since this color category Q turns into a color category to which a dispatch color vector belongs, as shown in candidate color vector Q', a call, and (several 11), it expresses these.
[Equation 11]

$$Q'_k = [r_{q_k}' \quad g_{q_k}' \quad b_{q_k}']^t \qquad k = 1,2,\cdots,m \qquad (11)$$

Here, m expresses the total of the color data classified into the color category Q of a liquid crystal display. When all the luminescent color colors of a liquid crystal display calculate the probability

generated from each color category, it asks for candidate color vector Q'. That is, the color data constellation from which the Mahalanobis distance of the color category Q becomes min among all the luminescent color colors of a liquid crystal display becomes candidate color vector Q'. Since candidate color vector Q' is chosen according to the color category to which a dispatch color vector belongs, it is necessary to put candidate color vector Q' in a database for every 11 color categories of a liquid crystal display beforehand.

[0062] As mentioned above, it is guaranteed by determining candidate color vector Q' of (several 11) that the consciousness category of the color displayed on a liquid crystal display becomes the same as that of CRT.

[0063] Next, the algorithm which extracts receiving color vector C' out of candidate color vector Q' is explained using drawing 7 and drawing 8 . It expresses with two-dimensional on account of declared.

[0064] The Ruhr at the time of mapping a dispatch color vector to a receiving color vector is as having been shown in drawing 3 (b), and maps the colors which are in agreement with category cull in the same color category field. for example, the black dot belonging to the green field (303) of the CRT display of drawing 3 (b) -- "green and yellow -- the color of a green boundary -- it is -- and -- among those, the category color" with the highest saturation -- cull description can be performed. such a category -- for aiming at mapping, maintaining cull implications -- a liquid crystal display -- setting -- "green and yellow -- the color of a green boundary -- it is -- and -- among those, color" with the highest saturation will be looked for. This is a black dot which belongs to the green field (304) of a liquid crystal display surely. the same -- both displays -- setting -- a black rectangular head -- "green and blueness -- the color of a green boundary -- it is -- and -- among those, color" with the highest saturation -- it is -- a white round head -- "green and yellow -- the color of a green boundary -- it is -- and -- among those, color" with the lowest saturation -- it is -- a white rectangular head -- "green and blueness -- the color of a green boundary -- it is -- and -- among those, saturation is lowest color" and they are the points which were in agreement with both category culls.

[0065] Thus, when it thinks, the point of having averaged four color data, a black dot, a black rectangular head, a white round head, and a white rectangular head, can be interpreted as in agreement with category cull among both displays. If the number of data is enough when four more color data are opened to all the color data constellations that constitute a color category, these averaged points can be interpreted as in agreement with category cull among both displays.

[0066] Then, as shown in drawing 7 , mean vector maps between the same color categories. the center of gravity given in drawing 7 as an average value of a color data constellation according to which Point G (701) was classified green in the CRT display -- expressing -- Point YG (702) -- a CRT display -- setting -- yellow -- the center of gravity given as an average value of a color data constellation according to which it was classified green -- expressing -- Point BG (703) -- a CRT display -- setting -- blueness -- the center of gravity given as an average value of a color data constellation according to which it was classified green is expressed. the center of gravity given on the other hand as an average value of a color data constellation according to which point G' (704) was classified green in the liquid crystal display -- expressing -- point YG' (705) -- a liquid crystal display -- setting -- yellow -- the center of gravity given as an average value of a color data constellation according to which it was classified green -- expressing -- point BG' (706) -- a liquid crystal display -- setting -- blueness -- the center of gravity given as an average value of a color data constellation according to which it was classified green is expressed. The center of gravity of 11 color categories is mapped among both displays as mentioned above.

[0067] Next, a center of gravity is considered to the pan of the center of gravity of three color categories of drawing 7 . Although drawing 8 (a) is the same as that of drawing 7 , Point O (801) is added to a CRT display, and point O' (802) is added to the liquid crystal display, respectively. Point O is the center of gravity of triangle G-YG-BG which the centers of gravity G, YG, and BG of three color categories of a CRT display form. the same -- a point -- O -- ' -- a liquid crystal display -- three -- a ** -- a color -- a category -- a center of gravity -- G -- ' -- YG -- ' -- BG -- ' -- forming -- a triangle -- G -- ' - YG -- ' - BG - - ' -- a center of gravity -- it is . It can be said that Point O and point O' also have the relation of mapping since three centers of gravity are points mapped by each among both displays as drawing 7 considered.

[0068] if the centers of gravity which are in the same color category among both devices are mapped wherever the location of the center of gravity of a dispatch device and a receiving device may be located like drawing 8 (b), although mapping between centers of gravity has been explained so far based on drawing 3 (b) -- a category -- cull relation can be saved. by the way -- although the point O (803) of drawing 8 (b) and point O' (804) are points mapped -- this time -- Segments LO, MO, and NO, L'O', M'O', and N'O -- ' -- die length -- a category -- it can be said that it has the same relation in the implications which form cull coincidence. therefore, a category -- in order to treat color-gamut mapping which saved cull relation, convenience is good when it normalizes in the distance from each color category connected to the point O of drawing 8 (b), and point O'.

[0069] The dispatch color C presupposes now that it generated in the location of Point O (803) temporarily. At this time, the dispatch color C and the distance of 11 color categories are expressed with (several 12).

[Equation 12]

$$D^2{}_{cj} = \left[C - \alpha_j\right]^t S_j^{-1}\left[C - \alpha_j\right] \qquad (12)$$

Here, D2Cj expresses the Mahalanobis distance from the center of gravity of the color category j to the dispatch color C. Moreover, it is [Equation 13] when distance of 11 color categories is set to (several 13) from Point O.

$$D^2{}_{oj} = \left[O - \alpha_j\right]^t S_j^{-1}\left[O - \alpha_j\right] \qquad (13)$$

Since the dispatch color C is on Point O (several 15) (several 14), it becomes.

[Equation 14]

$$D^2{}_{cj} = D^2{}_{oj} \qquad (14)$$

[Equation 15]

$$\frac{D^2{}_{cj}}{D^2{}_{oj}} = 1 \qquad (15)$$

And in a receiving device, it has the Mahalanobis distance as which the center of gravity of receiving color vector C' and 11 color categories is expressed in (several 16), and is [Equation 16].

$$D^2{}_{cj}' = \left[C' - \alpha_j'\right]^t S_j'^{-1}\left[C' - \alpha_j'\right] \qquad (16)$$

It is [Equation 17] when point O' has the Mahalanobis distance expressed in (several 17) as the center of gravity of 11 color categories.

$$D^2{}_{oj}' = \left[O' - \alpha_j'\right]^t S_j'^{-1}\left[O' - \alpha_j'\right] \qquad (17)$$

It is [(several 15) and] the same (several 18).

[Equation 18]

$$\frac{D^2{}_{cj}'}{D^2{}_{oj}'} = 1 \qquad (18)$$

In order to ******, receiving color vector C' needs to be the same as that of vector O'. therefore, receiving color C' -- point O' (804) -- being upwards is determined. All color category centers of gravity, and a call and its vector are called all color category mean vector here for the center of gravity of the center of gravity of Point O and 11 color categories like point O'. moreover (several 15) calls the distance which normalized the Mahalanobis distance (several 15) (**** -- D2 cj) from the center of gravity of a color category to a dispatch color in the Mahalanobis distance (several 15) (**** -- D2oj) from the center of gravity of the same color category to all color category centers of gravity

normalization dispatch color distance like. It is the same also at a receiving device.
[0070] It extends to the common case of drawing 8 (c) by the above view. It thinks by the left-hand side [of drawing 8 (c)], and dispatch device side first. Point P (805) is the location of a dispatch color, and the distance from the centers of gravity L, M, and N of three color categories is [Equation 19], respectively.

$$D^2{}_{PL} = [\mathbf{P} - \alpha_L]^t \mathbf{S}_j{}^{-1} [\mathbf{P} - \alpha_L] \qquad (19)$$

[Equation 20]

$$D^2{}_{PM} = [\mathbf{P} - \alpha_M]^t \mathbf{S}_j{}^{-1} [\mathbf{P} - \alpha_M] \qquad (20)$$

[Equation 21]

$$D^2{}_{PN} = [\mathbf{P} - \alpha_N]^t \mathbf{S}_j{}^{-1} [\mathbf{P} - \alpha_N] \qquad (21)$$

It comes out. however, P -- a dispatch color vector and alphaL -- in the mean vector of the color category M, and alphaN, the inverse matrix of the distributed covariance matrix of the color category L and S-1M show the inverse matrix of the distributed covariance matrix of the color category M, and, as for the mean vector of the color category L, and alphaM, the mean vector of the color category N and S-1L show S-1 N of inverse matrices of the distributed covariance matrix of the color category N, respectively. The distance from the centers of gravity L, M, and N of three color categories to all the color category centers of gravity O is [Equation 22], respectively.

$$D^2{}_{OL} = [\mathbf{O} - \alpha_L]^t \mathbf{S}_j{}^{-1} [\mathbf{O} - \alpha_L] \qquad (22)$$

[Equation 23]

$$D^2{}_{OM} = [\mathbf{O} - \alpha_M]^t \mathbf{S}_j{}^{-1} [\mathbf{O} - \alpha_M] \qquad (23)$$

[Equation 24]

$$D^2{}_{ON} = [\mathbf{O} - \alpha_N]^t \mathbf{S}_j{}^{-1} [\mathbf{O} - \alpha_N] \qquad (24)$$

It comes out. Therefore, the normalization dispatch color distance KPL of the point P of having seen from the color category L is [Equation 25].

$$K_{PL} = \frac{D^2{}_{PL}}{D^2{}_{OL}} \qquad (25)$$

The normalization dispatch color distance KPM of the point P of having seen from the next door and the color category M is [Equation 26].

$$K_{PM} = \frac{D^2{}_{PM}}{D^2{}_{OM}} \qquad (26)$$

The normalization dispatch color distance KPN of the point P of having seen from the next door and the color category N is [Equation 27].

$$K_{PN} = \frac{D^2{}_{PN}}{D^2{}_{ON}} \qquad (27)$$

It becomes.
[0071] Next, a right-hand side [of drawing 8 (c)] and receiving device side is considered. Point P' (806) is the location of a receiving color, L' is the center of gravity of the same color category as the color category L of a dispatch device, M' is the center of gravity of the same color category as the color category M of a dispatch device, and N' is the center of gravity of the same color category as the color category N of a dispatch device. a point -- P -- ' -- L -- ' -- M -- ' -- N -- ' -- from -- distance --

respectively -- [Equation 28]
$$D^2{}_{PL}' = [\mathbf{P}'-\alpha_L']^t \mathbf{S}_j'^{-1} [\mathbf{P}'-\alpha_L'] \quad (28)$$

[Equation 29]
$$D^2{}_{PM}' = [\mathbf{P}'-\alpha_M']^t \mathbf{S}_j'^{-1} [\mathbf{P}'-\alpha_M'] \quad (29)$$

[Equation 30]
$$D^2{}_{PN}' = [\mathbf{P}'-\alpha_N']^t \mathbf{S}_j'^{-1} [\mathbf{P}'-\alpha_N'] \quad (30)$$

It comes out. However, for the mean vector of the color category N, and SL'-1, the inverse matrix of the distributed covariance matrix of the color category L and SM'-1 are [P' / a receiving color vector and alphaL' / the mean vector of the color category L, and alphaM' / the mean vector of the color category M, and alphaN'] the inverse matrix of the distributed covariance matrix of the color category M, and SN'. - 1 shows the inverse matrix of the distributed covariance matrix of the color category N, respectively. three -- a ** -- a color -- a category -- a center of gravity -- L -- ' -- M -- ' -- N -- ' -- from -- all -- a color -- a category -- a center of gravity -- O -- ' -- up to -- distance -- respectively -- [Equation 31]
$$D^2{}_{OL}' = [\mathbf{O}'-\alpha_L']^t \mathbf{S}_j'^{-1} [\mathbf{O}'-\alpha_L'] \quad (31)$$

[Equation 32]
$$D^2{}_{OM}' = [\mathbf{O}'-\alpha_M']^t \mathbf{S}_j'^{-1} [\mathbf{O}'-\alpha_M'] \quad (32)$$

[Equation 33]
$$D^2{}_{ON}' = [\mathbf{O}'-\alpha_N']^t \mathbf{S}_j'^{-1} [\mathbf{O}'-\alpha_N'] \quad (33)$$

It comes out. therefore, the normalization dispatch color distance KPL of point P' seen from center-of-gravity L' of the color category L -- ' -- [Equation 34]
$$K_{PL}' = \frac{D^2{}_{PL}'}{D^2{}_{OL}'} \quad (34)$$

Normalization dispatch color distance KPM' of Point P seen from the next door and the color category M is [Equation 35].
$$K_{PM}' = \frac{D^2{}_{PM}'}{D^2{}_{OM}'} \quad (35)$$

Normalization dispatch color distance KPN' of Point P seen from the next door and the color category N is [Equation 36].
$$K_{PN}' = \frac{D^2{}_{PN}'}{D^2{}_{ON}'} \quad (36)$$

It becomes.
[0072] now, it defined by drawing 8 (b) -- as -- a category -- formation of cull matching means coincidence of the normalization dispatch color distance which the same color category has, and normalization receiving color distance. Therefore, in the case of drawing 8 (c), a receiving color vector is about the color category L (several 37).
[Equation 37]
$$K_{PL} = K_{PL}' \quad (37)$$

About
 color category M (several 38)
[Equation 38]

$$K_{PM} = K_{PM}' \tag{38}$$

About the color category N (several 39)
[Equation 39]

$$K_{PN} = K_{PN}' \tag{39}$$

it will not become, if there is no ********.
[0073] Actuation in which the above extracts receiving color vector C' out of candidate color vector Q' is [Equation 40].

$$K_{cj} = K_{cj}' \tag{40}$$

It is equivalent to discovering the color vector which can be filled with the smallest possible error out of candidate color vector Q' to all 11 color categories. Kcj expresses the normalization dispatch distance at the time of seeing the dispatch color vector C from the color category j here, and Kcj' expresses the normalization receiving distance at the time of seeing receiving color vector C' from the color category j. So, (several 41) is used for an error valuation plan.
[Equation 41]

$$E = \frac{K_{c1}'}{K_{c1}} \times \frac{K_{c2}'}{K_{c2}} \times \cdots\cdots \times \frac{K_{cj}'}{K_{cj}} \times \cdots\cdots \times \frac{K_{c11}'}{K_{c11}} \tag{41}$$

However, it sets in the color category j (several 42).
[Equation 42]

$$\frac{K_{c1}'}{K_{c1}} < 1 \tag{42}$$

It is [several 43] at the time of ******.

$$\frac{K_{c1}'}{K_{c1}} \tag{43}$$

It replaces with ** (several 44).
[Equation 44]

$$\frac{K_{c1}}{K_{c1}'} \tag{44}$$

The color vector which makes (several 41) min among candidate color vector Q' is made into receiving color vector C'.
[0074] In the above, the part which performs the algorithm which extracts candidate color vector Q' to receiving color vector C' is explained in drawing 1 . This actuation is divided into the following four processes.
All color category mean vector is computed in both a process 1. CRT display and a liquid crystal display (104 of drawing 1 , 105).
In a process 2. CRT display, normalization dispatch color distance (107 of drawing 1) is computed using the mean-vector [of the color category Q], distributed covariance vector (106 of drawing 1), and dispatch color vector (101 of drawing 1) all color category mean vector (104 of drawing 1).
In a process 3. liquid crystal display, normalization receiving color distance (109 of drawing 1) is computed using mean-vector [of the color category Q], distributed covariance vector (108 of drawing 1), and candidate color vector Q' (103 of drawing 1), and all color category mean vector (105 of drawing 1).
To each color category of 4.11 processes, normalization dispatch color distance is compared with normalization receiving color distance between a CRT display and a liquid crystal display (110 of drawing 1), the color vector to which the error of distance becomes small most is selected out of

candidate color vector Q', and this is made into drive signal C' of a liquid crystal display (111 of drawing 1).
[0075] Setting in a process 1, all color category mean-vector O of a CRT display is [Equation 45].

$$\mathbf{O} = \begin{bmatrix} \frac{\sum_{j=1}^{n} \bar{r}_j}{n} & \frac{\sum_{j=1}^{n} \bar{g}_j}{n} & \frac{\sum_{j=1}^{n} \bar{b}_j}{n} \end{bmatrix} \quad (45)$$

It is come out and given. n is the number of color categories and is n= 11 with this operation gestalt.
Moreover, all color category mean-vector O' of a liquid crystal display is [Equation 46].

$$\mathbf{O}' = \begin{bmatrix} \frac{\sum_{j=1}^{n} \bar{r}_j'}{n} & \frac{\sum_{j=1}^{n} \bar{g}_j'}{n} & \frac{\sum_{j=1}^{n} \bar{b}_j'}{n} \end{bmatrix} \quad (46)$$

It is come out and given. n is the number of color categories and is n= 11 with this operation gestalt.
[0076] Setting in a process 2, the normalization dispatch color distance Kcj is [Equation 47].

$$K_{cj} = \frac{D_{cj}}{D_{co}} \quad (47)$$

It is come out and given. Dcj expresses the Mahalanobis distance from the center of gravity of the color category seen from the color category j to the dispatch color C here, and Doj expresses the Mahalanobis distance from the center of gravity of the color category seen from the color category j to all color category centers of gravity.
[0077] Setting in a process 3, normalization receiving color distance Kcj' is [Equation 48].

$$K_{cj}' = \frac{D_{cj}'}{D_{co}'} \quad (48)$$

It is come out and given. Dcj' expresses the Mahalanobis distance from the center of gravity of the color category seen from the color category j to receiving color C' here, and Dco' expresses the Mahalanobis distance from the center of gravity of the color category seen from the color category j to all color category centers of gravity.
[0078] - (several 44) is used for error evaluation (several 41) of normalization dispatch color distance and normalization receiving color distance in a process 4.
[0079] as mentioned above, the color on a CRT display (r, g, b) is mapped by the color on a liquid crystal display monitor (r', g', and b -- '), these two pairs have the same color category, and since the relative location within a color category is the same, it can perform color-gamut mapping by the natural tint. Furthermore, the above-mentioned technique has the uniqueness which is not in the conventional technique, and the design of an image device and the color reproduction system of software and the color management in each user site can enforce it effectively.
[0080] In addition, it can be understood easily that it can use for correspondence color prediction if two color charts which observed the CRT display and the liquid crystal display under the environment where the sources of the illumination light differ, respectively are considered, and it can use for property adjustment of a device if a CRT display and a liquid crystal display are caught with the two properties of a single device that properties differed by aging etc.
[0081] Namely, when returning the current property of a single device that input-output behavioral characteristics changed with change of a condition to the original property, it sets. Present condition voice and the color space which chrominance-signal data form for every former condition are divided

into two or more color categories by settlement of the color which an observer perceives. The probability density function which makes the population the chrominance-signal data constellation classified into the same color category is created. The color category to which said former condition color vector belongs according to the probability of occurrence which the former condition color vector which is the color information which said former condition has generates from each color category is determined. out of the chrominance-signal data constellation of the present condition voice generated out of the same color category as the color category to which said former condition color vector belongs Chrominance-signal data with which physical relationship with the center-of-gravity point of each color category of present condition voice becomes the closest to the physical relationship which said former condition color vector has with the center-of-gravity point of each color category of a former condition are selected as a present condition color vector.
[0082] (Gestalt 2 of operation) The procedure which outputs the color of a CRT display to 4 color printer next is explained, using drawing 9 as a gestalt 2 of operation.
[0083] When changing the color (r, g, b) of a CRT display into the color (c, m, y, k) of 4 color printer, as shown in drawing 10 R> 0, it turns out that color-gamut mapping is needed from the difference in the color specification range of both devices. Drawing 10 is an example of the color specification range of the NTSC standard, and the color reproduction range of an ink jet printer, and is data which this invention person actually measured. Drawing 10 (a) is drawing which projected the colorimetry value of the representation color of a CRT display and an ink jet printer on the a*-b* flat surface of CIELAB space, drawing 10 (b) is drawing which projected the colorimetry value of the representation color of a CRT display and an ink jet printer on the L*-a* flat surface of CIELAB space, and drawing 10 (c) is drawing which projected the colorimetry value of the representation color of a CRT display and an ink jet printer on the L*-b* flat surface of CIELAB space.
[0084] Drawing 10 (a) In - (c), white rectangular heads are the primary color (C, M, Y) of an ink jet printer, a secondary color (C+M, M+Y, Y+C), and a gray representation color. Moreover, white trigonums are the primary color (R, G, B) of the CRT display in accordance with the NTSC standard, a secondary color (R+B, R+G, G+B), and a gray representation color. Furthermore, a sunspot is representation color 729 color of an ink jet printer, and is uniformly chosen from the whole color specification range of an ink jet printer. 1001 of drawing 10 expresses the appearance of the color specification range of a CRT display, and 1002 expresses the appearance of the color specification range of an ink jet printer.
[0085] Color-gamut mapping with this operation gestalt is mapping of three-dimension space and 4-dimensional space. Since number of dimensions differ, the approach used with "the gestalt 1 of operation" is inapplicable as it is. Then, it maps by dropping the number of dimension of a printer on a three dimension by the approach shown in drawing 11 . The representation color of a printer is first selected out of the inside of CMY three-dimension space (1101 of drawing 11). The selected color vector E serves as an element of the chrominance-signal data constellation of each color category, and it is used in order to describe the probability density function of a color category.
[0086] On the other hand, the color stimulus (1102 of drawing 11) shown to a test subject is [Equation 49] which performed Japanese ink generating and lower color removal (1103 of drawing 11) to the color vector E.

$$\begin{aligned} \mathbf{E}_p &= \begin{bmatrix} c_p & m_p & y_p & k \end{bmatrix}^T \\ \varepsilon &= \min(c, m, y) - \rho \geq 0 \\ c_p &= c - \tau_c \varepsilon \\ m_p &= m - \tau_m \varepsilon \\ y_p &= y - \tau_y \varepsilon \\ k &= \phi \varepsilon \end{aligned} \qquad (49)$$

A printer is driven and created by the becoming color vector EP (1104 of drawing 11). Setting to (several 49), min (c, m, y) is c. m The function which detects the minimum value of y is expressed. rho, tauc, taum, and tauy and phi are arbitrary constants, respectively. It does not pass over (several 49) to an

example of Japanese ink generating and lower color removal, but it can apply the Japanese ink generating approach of arbitration, and the lower color removal approach to this invention.
[0087] Since a three dimension can describe the probability density function formed in printer space by the above actuation, the procedure of color-gamut mapping shown in drawing 9 is fundamentally [as drawing 1] the same. However, after receiving color vector C' can be found, as shown in 901 of drawing 9 , Japanese ink generating and lower color removal are performed. And Japanese ink generating of drawing 9 of 901 and lower color removal must be the same as that of 1103 of drawing 11 . 902 which is the output of 901 becomes a mapping point.
[0088] As mentioned above, he can understand color-gamut mapping, correspondence color prediction, and that device property adjustment can be performed further from the gestalt of this operation also by 4 color printer by which the color space and number of dimension of a CRT display differ from each other.
[0089] In addition, although the color information-interchange approach of of "the gestalt 1 of operation" and the "gestalt 2 of operation" and the adjustment approach of a device property were explained using the chrominance signal depending on devices, such as RGB and CMYK, the same operation gestalt can be performed by modeling the relation between a device signal and a colorimetry value also in colorimetry value space. For example, at the NTSC standard, it is [Equation 50].

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0.6067 & 0.1736 & 0.2001 \\ 0.2988 & 0.5868 & 0.1144 \\ 0.0000 & 0.0661 & 1.1150 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \qquad (50)$$

[Equation 51]

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1.9106 & -0.5326 & -0.2883 \\ -0.9843 & 1.9984 & -0.0283 \\ 0.0584 & -0.1185 & 0.8985 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix} \qquad (51)$$

Conversion of an RGB code and XYZ tristimulus values is possible in be alike. With input devices, such as a camera, the incorporated RGB code can be changed into XYZ tristimulus values by (several 50), and it can change into the XYZ tristimulus values of the color displayed by (several 51) by the driven RGB code with output equipment, such as a CRT display. If convertible for XYZ tristimulus values, since it is convertible for other colorimetry value space, such as CIELAB and CIELUV, it can be understood easily that a color space can be chosen as arbitration. It asks for the function which connects a device signal and a colorimetry value as shown in (several 50) and (several 51), and also all conversion information is formed into a direct table, or conversion information is searched for from representation color data, and if the relation between a device signal and a colorimetry value is decided in the form of compensating all conversion information by the interpolation operation, color information interchange and adjustment of a device property can be performed in colorimetry value space.
[0090] In addition, as compared with mapping according mapping by this operation gestalt 1 or device signal like 2 to a colorimetry value, it turns out that it has this operation gestalt 1 and the description that a colorimetry activity is not required of 2.
[0091]
[Effect of the Invention] According to this invention, it can opt for color-gamut mapping with the uniqueness which is not in the conventional technique as mentioned above. And the outstanding color information-interchange approach that improvement in the color reproduction nature of the image between the devices with which observation conditions differ etc. is realizable is realizable.
[0092] Moreover, according to this invention, the outstanding device property adjustment approach that improvement in the color reproduction nature of the image with which the adjustment approach of a device property can be determined with the uniqueness which is not in the conventional technique, and observation conditions differ etc. is realizable is realizable.

[Translation done.]